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HOSPITAL SOLID WASTE DISPOSAL IN COMMUNITY FACILITIES

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This study considers various aspects of handling hospital solid waste from the areas of generation to the sites of ultimate disposal. A number of factors related to the quantity of solid waste per patient are identified, and certain of the most important factors are included in an equation. This and other results of the study should have value to many persons interested in solid waste handling at hospitals.

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REVIEW NOTICE

The Solid Waste Research Laboratory of the National Environmental Research Center - Cincinnati, U.S. Environmental Protection Agency, has reviewed this report and approved its publication. Approval does not signify that the contents necessarily reflect the views and policies of this laboratory or of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

In an attempt to solve the problem of solid waste disposal, this study examines the various aspects of handling hospital solid waste. This report, published by the National Environmental Research Center - Cincinnati, develops a quantitative evaluation of the problem of hospital solid waste handling and disposal.

A. W. Breidenbach, Ph.D.
Director
National Environmental
Research Center - Cincinnati

ABSTRACT

In recent years a number of studies have been made of a solid waste problem for one or another health care institution. The purpose of this study was to develop a quantitative evaluation of the problem of solid waste handling and disposal for a number of general hospitals selected randomly throughout the United States. Specifically, the study attempted to obtain data on both volume and density of the waste, related to various parameters of the hospital and the community; sources of waste in the hospital; collection and processing practices, and disposal practices in the community, and the impact of such wastes on the community's collection and disposal system. Such data were obtained from more than 100 hospitals ranging in size from 50 to 1,000 beds.

Visits were made to each hospital and measurements were made of volume and density of waste generated over a 24-hour period. To the extent possible, sources of wastes in the institution were identified. Related information about the characteristics of the hospital was obtained. Of particular interest, in addition to the usual patient and employee census data, were the services and facilities provided, training and research programs, and physical plant characteristics. Nearly 1,000 items were included in the survey procedure suitably coded to facilitate analysis of any combination of the data from any grouping of hospitals, services, patient census, or community characteristics. Comparisons were made on the basis of such hospital characteristics as bed capacity, operating room data, outpatient data, obstetrical services, number of employees and patient census.

More than 70 tables were prepared from the data relating to geographic

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distribution of the surveyed hospitals, community characteristics, size and construction dates of the institution, frequencies of collection and amounts of wastes, weight and volumes of wastes compared to ranges of bed capacity, number of operating rooms, surgical procedures, and outpatient visits. Likewise, comparisons of weight and volume were made with other selected combinations of hospital facilities and services.

Detailed information is reported on mean loads of wastes collected during peak hours, and relationships to hours of operation of incinerators. Extensive data are provided on the use of incinerators in this sample of hospitals including design features, loading and operating practices, and problems related to these operations. Data on use of grinders and other methods of processing, including special handling of hazardous wastes, are included.

Information is provided on the practices in the community for transportation and disposal of hospital wastes. For example, much of the hauling was done by private contractors, with many of the hospitals being served by more than one hauler. Most of the waste was disposed of in a municipal facility -- most of these in turn being open dumps.

The study attempted to report on findings having public health implications. Practices that might contribute to contamination in the hospital were noted. Also, practices that could cause injury to employees were evident. Of special note were the hazards associated with operation of the incinerators. Use of untrained personnel compounded this problem.

Disposal of untreated hospital wastes in dumps, and even feeding of food wastes to hogs, demonstrate a shared hospital-community problem area.

The recommendations in the report call attention especially to the need to assign more qualified personnel to this important service function in nearly all of the hospitals that were studied.

As with most such ambitious studies, more questions were raised than were answered.

ACKNOWLEDGMENTS

During the three years that this study was under way a great many individuals made valuable contributions toward its success. The initial studies were greatly facilitated by the cooperation and assistance of the Twin Cities Hospital Association and a number of its member institutions. The second stage of the study, involving 25 hospitals located around the Country, was aided immeasurably by the interest of the graduates of the Program in Hospital and Health Care Administration of the School of Public Health who were serving as Administrators in those hospitals.

The full-scale study, involving 80 participating institutions, was dependent on the support of many individuals - administrators, department heads and staff who welcomed us into their hospitals and contributed both time and effort to make the surveys as complete and accurate as their resources would permit. To these several hundred friends, we wish to express a special word of thanks. Municipal officials, including those in local public health departments, and those responsible for solid waste collection and disposal were most cooperative and helpful.

Many colleagues in the School of Public Health assisted in a variety of ways. Faculty in the Department of Biometry, School of Public Health assisted from the beginning of the study to its ultimate conclusion. For such professional and personal support we are most appreciative.

Lastly, but possibly first in order of necessity, our thanks for generous financial support provided by the Solid Waste Management Office, Environmental Protection Agency.

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HOSPITAL SOLID WASTE DISPOSAL IN COMMUNITY FACILITIES

I. INTRODUCTION

In the present period of public concern for environmental control, solid waste has been receiving increasing attention. Solid waste generated at hospitals, although only a very small part of all solid waste, is particularly important both for the hospital and for the community because of considerations of environmental health and safety, as well as efficiency of handling. The importance of adequate management of hospital solid waste has received recognition, as evidenced by the many articles regarding this topic appearing in hospital publications. However, there have been only a very few comprehensive studies reported regarding solid waste from hospitals. There is a particular lack of reliable data on the quantity of such waste material and on disposal in the community away from the hospital.

The Problem

Statement of Research Purpose. The purpose of the study was to develop a quantitative evaluation of the problem of hospital solid waste handling and disposal. Specific objectives included

(1) determination of total weights of solid waste generated at hospitals, and relation to bed capacity and number of patients, (2) determination of quantities of solid waste per patient, and relations to hospital and community characteristics, (3) evaluation of the composition of hospital waste according to type of material, (4) determination of densities of types of materials comprising hospital solid waste, (5) evaluation of sources of solid waste within the hospital, (6) development of quantitative information regarding the collection of solid waste within the hospital, including number of loads of waste collected per day, size of loads, and quantities of solid waste collected during the peak hour, (7) evaluation of methods of disposal of hospital solid waste, including any material hauled from the hospital, and (8) evaluation of the impact of hospital solid waste on community solid waste collection and disposal systems.

Importance of the Research. In 1968 there were 7,137 hospitals of all types in the United States, having a total of 1,663,203 beds and admitting almost thirty million patients. In the same year, hospital employees totaled over 2,300,000; assets were more than thirty-one billion dollars; and annual expenditures exceeded nineteen billion dollars.[6] The large size of the hospital industry in the United States relates to the importance of the study. An increase in the efficiency of hospital solid waste collection, for example, could result in a considerable total savings in cost, if achieved in a large proportion of the nation's hospitals. Similarly, improvement in the sanitation of solid waste handling at hospitals could lead to widespread benefits.

Adequate management of hospital solid waste has importance at the hospital and elsewhere in the community. At the hospital, improper handling and disposal of solid waste may create health and safety hazards for patients, staff, visitors, and volunteers. Inefficient handling of solid waste would lead to increased cost for hospital patients. Hospital solid waste has environmental health and safety implications for the community, in terms of possible air pollution from incineration at the hospital, possible water pollution from solid wastes disposed of to public sewers, and hazards from solid waste hauled away from the hospital. The hauling of solid waste from hospitals requires careful consideration, since widespread inadequacies exist at disposal sites.[27]

The data developed in the study have additional significance. Consultants need the information for designing solid waste management systems for hospitals. Hospital administrators and other personnel should find the data useful in the operation of hospitals. Governmental agencies might find the data from this study useful in the development of standards for hospital solid waste management. The significance of data from the research should grow as the number and size of hospitals increase, and the quantity of solid waste from hospitals continues to mount.

Definition of a Hospital and Diversity of Hospitals in the United States

Definition of a Hospital. Table 1 lists the requirements of the American Hospital Association for registration of a hospital. This constitutes a definition of a hospital and is the definition used in the research. Included are specifications for at least six beds, regular care by a qualified doctor, adequate nursing care, and other requirements. For comparison, the definition of a hospital presented by the Minnesota State Board of Health is as follows:[213]

> A hospital is an institution adequately and properly staffed and equipped, providing services, facilities and beds for the reception and care for a continuous period longer than 12 hours for one or more nonrelated persons requiring diagnosis, treatment or care for illness, injury or pregnancy; and regularly making available clinical laboratory services, diagnostic x-ray services, and treatment facilities for (a) surgery or (b) obstetrical care or (c) other definitive medical treatment of similar extent.

Diversity of Hospitals in the United States. The preceding definitions give little indication of the great diversity among American hospitals. Table 2 indicates a classification of hospitals by control, as presented by the American Hospital Association.[6] Hospitals may have governmental or nongovernmental

TABLE 1

REQUIREMENTS OF THE AMERICAN HOSPITAL ASSOCIATION FOR REGISTRATION OF HOSPITALS*

Any institution that can be classified as a hospital according to the requirements may be registered if it so desires. Membership in the American Hospital Association is not a prerequisite.

Requirements for accepting hospitals for registration†

---

1. The hospital shall have at least six beds for the care of patients who are nonrelated, who are sick, and who stay on the average in excess of 24 hours per admission.

2. The hospital shall be constructed, equipped, and maintained to ensure the safety of the patients, and shall provide uncrowded and sanitary facilities for the treatment of individuals accepted for care.

3. Doctors of medicine, doctors of osteopathy, and doctors of dentistry may admit patients to hospitals registered by the American Hospital Association. (Patients admitted to the hospital by doctors of dentistry must have an admission history and physical examination done by a doctor of medicine or doctor of osteopathy on the staff of the hospital, and the doctor of medicine or osteopathy shall be responsible for the patient's medical care throughout his stay.)

4. There shall be an organized medical staff (which may include doctors of osteopathy and dentistry) governed by bylaws adopted by said staff and approved by the governing board of the hospital.

5. The hospital shall submit evidence of regular care of the patient by a doctor of medicine, doctor of osteopathy, or doctor of dentistry and of general supervision of the clinical work by doctors of medicine.

TABLE 1 (continued)

6. Records of clinical work shall be maintained by the hospital on all patients and shall be available for reference.

7. Registered nurse supervision and such other nursing service as is necessary to provide patient care round the clock shall be available at the hospital.

8. The hospital shall offer services more intensive than those required merely for room, board, personal services, and general nursing care.

9. Minimal surgical or obstetrical facilities (including operating or delivery room), or relatively complete diagnostic facilities and treatment facilities for all patients, shall be available at the hospital.

10. Diagnostic x-ray services shall be regularly and conveniently available.

11. Clinical laboratory services shall be regularly and conveniently available.

The American Hospital Association may, at the sole discretion of its Board of Trustees, grant, deny, or withdraw the registration of an institution.

AOHA-LISTED HOSPITALS

The listing of osteopathic hospitals is furnished by the American Osteopathic Hospital Association and includes both members and nonmembers of that organization.

†Requirements approved by the Board of Trustees, May 1955, and adopted by the House of Delegates, September 1955. Amended June 1956; February 1957; August 1959; May 1963; May 1964; and February 1965.

---

*From 1969 "Guide Issue" of Hospitals, Journal of the American Hospital Association.[6]

TABLE 2

CLASSIFICATION OF HOSPITALS IN THE UNITED STATES ACCORDING TO CONTROL*

- I. Governmental
  - A. Federal
    - 1. Air Force
    - 2. Army
    - 3. Navy
    - 4. Public Health Service, Indian Service
    - 5. Public Health Service, other than Indian Service
    - 6. Veterans Administration
    - 7. Justice Department
    - 8. Other Federal
  - B. Nonfederal
    - 1. State
    - 2. City
    - 3. County
    - 4. City-County
    - 5. Hospital district or authority
- II. Nongovernmental
  - A. Nonprofit
    - 1. Church operated
    - 2. Other nonprofit
  - B. For-profit
    - 1. Individual
    - 2. Partnership
    - 3. Corporation
- III. Osteopathic Hospitals
  - A. Nonprofit
    - 1. Church operated
    - 2. Other nonprofit
  - B. For-profit
    - 1. Individual
    - 2. Partnership
    - 3. Corporation

---

*From 1969 "Guide Issue" of Hospitals, Journal of the American Hospital Association.[6]

control, and among the latter, may be either nonprofit or for-profit. Among the types of hospitals listed according to control, nongovernmental, nonprofit hospitals have been increasing as a fraction of both the total number of hospitals and the total number of beds in hospitals. Presently, the nongovernmental, nonprofit category includes almost one-half of all hospitals in the United States, and accounts for two-thirds of the annual number of admissions to hospitals.[6]

Classification of hospitals by type of service, according to the American Hospital Association, is presented in Table 3. The types of hospitals include hospitals having general medical and surgical service, as well as those providing numerous types of specialized service. Of the types of hospitals listed, those providing general medical and surgical care include more than 75 percent of all hospitals in the United States, and more than 50 percent of all beds in hospitals. Further, hospital statistics for the past 25 years indicate that general hospitals are increasing in both number of institutions and number of beds relative to hospitals of other classifications.[3,6]

There is a wide diversity even among hospitals which are in the same categories of control and service. An important area of diversity is size of hospital. Nongovernmental, nonprofit hospitals range in size from under 25 beds to more than 1,000 beds.[6] General hospitals also vary greatly in facilities and

TABLE 3

CLASSIFICATION OF HOSPITALS IN THE UNITED STATES ACCORDING TO SERVICE*

1. General medical and surgical
2. Hospital unit of an institution
3. Psychiatric
4. Tuberculosis
5. Narcotic
6. Geriatric
7. Maternity
8. Eye, ear, nose, and throat
9. Physical rehabilitation
10. Orthopedic
11. Chronic
12. Other specialty
13. Institution for mental retardation
14. Epilepsy
15. Alcoholism and/or addictive diseases
16. Children's
    - a. General
    - b. Psychiatric
    - c. Eye, ear, nose, and throat
    - d. Physical rehabilitation
    - e. Orthopedic
    - f. Other specialty

---

*From 1969 "Guide Issue" of Hospitals, Journal of the American Hospital Association.[6]

services, in participation in educational programs, in community setting, and in numerous other respects.[202]

Definition and Diversity of Solid Waste

The American Public Works Association has defined waste as "useless, unwanted, or discarded materials resulting from normal community activities." Refuse was considered to comprise "all of the solid wastes of the community," including "semi-liquid or wet wastes with insufficient moisture and liquid contents to be free-flowing."[13] The definition appears to include household, institutional, commercial, industrial, and certain other solid waste, and was considered satisfactory for purposes of this research.

Table 4 presents a classification scheme for solid waste, as adapted from material presented by the American Public Works Association.[12] Hospital solid waste includes, among the types of waste listed in Table 4, garbage, combustible rubbish, noncombustible rubbish, ashes, and demolition and construction refuse. The descriptions of these six types of waste, given by the American Public Works Association, were used in the research. In addition, hospital solid waste was considered to include two special wastes, biological materials and radioactive solid waste. Biological materials were considered to include human tissue, bacteriological cultures, stool specimens, animal remains, and

TABLE 4

DESCRIPTION OF TYPES OF SOLID WASTE*

Type	Description
Garbage	Wastes from preparation, cooking, and serving of food; market wastes; wastes from handling, storage, and sale of produce
Rubbish	Combustible: paper, cartons, boxes, barrels, wood, excelsior, tree branches, yard trimmings, wood furniture, bedding, dunnage
	Noncombustible: metals, tin cans, metal furniture, dirt, glass, crockery, minerals
Ashes	Residue from fires used for cooking and heating and from on-site incineration
Street refuse	Sweepings, dirt, leaves, catch basin dirt, contents of litter receptacles
Dead animals	Cats, dogs, horses, cows
Abandoned vehicles	Unwanted cars and trucks left on public property
Industrial wastes	Food processing wastes, boiler house cinders, lumber scraps, metal scraps, shavings
Demolition wastes	Lumber, pipes, brick, masonry, and other construction materials from razed buildings and other structures
Construction wastes	Scrap lumber, pipe, other construction materials

TABLE 4 (continued)

Type	Description
Special wastes	Hazardous solids and liquids: explosives, pathological wastes, radioactive materials
Sewage treatment residue	Solids from coarse screening and from grit chambers; septic tank sludge

*From Municipal Refuse Disposal.[12]

other materials. Radioactive waste included solid waste of any kind contaminated with radioactive material having detectable activity.

Types of Community Solid Waste Collection and Disposal Systems

Systems for Collection of Solid Waste. The American Public Works Association described collection of community solid waste by municipal, contract, and private systems, and by combinations of these.[13] Table 5 defines these collection systems. A contract system, for example, is one in which a municipality engages and pays a private hauler to collect solid waste under specified conditions. Frequently, a combination of collection systems exists in a community. Private collection of solid waste fills an important need in communities where there is no other type of solid waste collection and in other communities where collection service is not provided to certain types of establishments. Hospitals, industries, and commercial establishments are frequently customers of private haulers and, in other instances, either haul their own solid waste or are served by municipal agencies.

Systems for Disposal of Solid Waste. Disposal of solid waste collected in the United States is by dumping, sanitary landfill, incineration, central grinding with discharge to sewage

TABLE 5

DEFINITION OF TYPES OF SOLID WASTE COLLECTION SYSTEMS*

Type of Collection System	Definition
Municipal	"'Municipal collection' involves the performance of the collection operation by city employees and equipment under the supervision of a regular municipal department or official. . . ."
Contract	"'Contract collection' consists of the engagement by cities of private companies under formal agreements and definite specification to collect and haul municipal refuse, for which the haulers are paid from general public revenues or service fees collected by the city."
Private	"'Private collection' involves the collection by individuals or companies of refuse materials from private properties, the arrangements for which services are made directly between the owner or occupier of the premises and the collector."

*From Refuse Collection Practice.[13]

systems, composting, salvage, and hog feeding. Of these methods, dumping, sanitary landfill, incineration, and hog feeding are most frequently involved in the disposal of solid waste hauled from hospitals in the United States.

Dumping and sanitary landfill. Land disposal by dumping or sanitary landfill is most commonly used for the disposal of solid waste after collection. A recent report, which included data for 46 percent of the population of the United States, indicated that there are approximately 6,000 land disposal sites, compared with only 142 incinerators and 262 hog feeding establishments.[27]

A careful distinction should be made between disposal by dumping, which invariably is associated with environmental sanitation hazards, and disposal by sanitary landfill, which is designed to protect the public health. Sanitary landfill has been described as follows by the American Society of Civil Engineers:[14]

> Sanitary landfill is a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation or at such more frequent intervals as may be necessary.

Environmental sanitation problems which can be caused by disposal of solid waste in dumps include water pollution, air pollution, insect breeding, rodent harborage and breeding and safety problems. Nevertheless, a recent report indicated that 94 percent of the land disposal sites considered were dumps, rather than sanitary landfills.[27]

Incineration. Incineration has been used by fewer communities than has land disposal, with higher cost being an important reason. Nevertheless, incineration has important advantages, including lesser land requirement than sanitary landfill, possibility of location close to collection area, operation less affected by weather conditions than sanitary landfill, and other advantages.[30] A recent report indicated that incinerators have problems with blowing paper, unsightliness, air pollution, flies, rodents, dust, odor, and water pollution control.[218] Disposal of the residue from incineration is by open dumping at many facilities.

Hog Feeding. The feeding of food waste to hogs has declined considerably in recent years. The most important public health problem associated with the feeding of garbage to hogs has been the transmission of the parasite, Trichinella spiralis, to hogs, with man contracting the disease trichinosis by ingesting raw or inadequately cooked meat from infected pigs. Cooking of garbage before feeding to hogs is now generally required in the United States and effectively prevents transmission of the parasite.[118] Environmental sanitation problems at hog feeding establishments have been reported to include odor, presence of flies, and rodent infestation. Garbage from such places as restaurants, military establishments, and hospitals has been preferred for hog feeding.[12]

II. REVIEW OF THE LITERATURE

Hospital solid waste and the many related topics have received considerable comment in the literature. This review summarizes selections from that literature believed to be particularly relevant to this research.

Classification, Quantities, and Composition of Hospital Solid Waste

Classification of Hospital Solid Waste. The Committee on Hospital Facilities, Engineering and Sanitation Section, of the American Public Health Association presented (1956) descriptions (summarized below) of types of hospital solid waste:[11]

1. Garbage.
2. Rubbish, in which the Committee included both combustible and noncombustible solid waste.
3. Ashes.
4. Biological waste, which the Committee considered to comprise that "resulting directly from patient care activities, such as diagnostic procedures and treatment." Types of biological waste, considered to "include materials of medical, surgical, autopsy, and laboratory origin, were listed as follows:

a) Medical waste, which was considered to include such items as "gauze dressings and bandages, swabs, cartons, and plaster casts," as well as "sputum cups and paper bags containing paper tissues soaked with secretions of the nose or throat from tuberculosis and other infectious disease cases."

b) Surgical and autopsy waste, which was considered to include "amputated limbs, tissues and organs, placenta[s], and similar types of material."

Other classification schemes for hospital solid waste have been presented and are summarized in Table 6. However, the classification presented by the American Public Health Association was undoubtedly more generally accepted than the others.

Quantities of Hospital Solid Waste. The literature included many reports on the quantity of solid waste from hospitals. Table 7 summarizes available data on contributions of solid waste per day, based on the number of patients or the number of beds in the hospital. The four values noted for European practice indicate waste contributions far lower than those for the United States. The values overall indicate an

TABLE 6

CLASSIFICATION SCHEMES FOR HOSPITAL SOLID WASTE, AS SUMMARIZED FROM VARIOUS SOURCES

Author	Year Presented	Classes of Hospital Solid Waste	Reference
Deming	1958	Ordinary floor waste (e.g., paper), kitchen waste, pathological waste, X-ray and cast room waste, receiving room waste (e.g., large cartons), metal, and glass.	72
McKenna	1963	Garbage, rubbish, ashes, pathological waste, critical waste (e.g., radioactive), and pathogen-contaminated waste.	203
Falick	1965	Garbage, rubbish, organic waste ("animal carcasses, organs, solid organic waste, and pathological waste"), other waste (rubber, plastics, metals, glass, etc.), and special waste ("radioactive and other waste representing a high degree of danger if handled and, [which] therefore, must be disposed of by separate means, by law").	93

TABLE 6 (continued)

Author	Year Presented	Classes of Hospital Solid Waste	Reference
Black	1967	Garbage, "paper, trash, and other dry combustibles", treatment room waste, surgery waste, autopsy waste, and noncombustibles.	26
Holbrook	1968	Garbage and similar material capable of being ground for discharge to a sewerage system, "wet waste incompatible with the sewer and difficult to burn", combustible waste, "pathological and radioactive wastes, which require special treatment because of contamination and which are usually regulated by statute", and noncombustible waste.	140
Groce	1968	Garbage, rubbish, pathological waste (including body tissues, fluids, and bones), and infectious waste.	123

TABLE 7

CONTRIBUTIONS OF HOSPITAL SOLID WASTE PER PATIENT PRESENTED IN VARIOUS REFERENCES

Source	Year Presented	Contribution of Solid Waste	Reference
Overton	1937	7 lb/day/bed*, comprising 40 percent to 50 percent garbage, and the balance rubbish.	231
Olson	1949	7.5 lb/day/bed*, compared with "government estimates" of 8 to 8.5 lb/day/bed*. The latter included 4 lb/day/bed* of "kitchen garbage."	227
American Hospital Association, Manual of Hospital Housekeeping	1952	7 lb/day/patient, average generation.	8
Incinerator Institute of America, "Bulletin H"	1955	Design basis for incinerators of 8 lb/day/bed*, plus 3 lb/day for each person in an "auxiliary section" (e.g., nurse's residence), plus 1 lb/patient in outpatient department. If garbage were excluded the first value might be reduced to 5 lb/day/bed.* Base incinerator design on 7 hr/day.	160

TABLE 7 (continued)

Source	Year Presented	Contribution of Solid Waste			Reference
American Public Health Association	1956	Mean Contributions:	lb/day/ patient	cu ft/day/ patient	11
		Garbage	3.28	0.064	
		Noncombustibles	1.10	0.111	
		Combustibles	2.61	0.521	
		Surgical and autopsy waste	0.14	omitted	
			7.13	0.696	
Sister M. Clarisse	1958	7 lb/day/patient, for general hospitals.			54
Vance	1961	7 lb/day/patient, or almost 1 cu ft/day/ patient.			293
Institutions Magazine	1961	7 to 8 lb/day/bed.*			108
Minerath (France)	1962	0.4 liter/day/bed*, apparently for wards only.			209
Briosi (Italy)	1963	2 to 3 liters/day/patient.			39
Heyer (Germany)	1963	1 liter/day/patient.			136
McKenna	1963	9.6 lb/day/bed*, or 1.7 cu ft/day/bed* for a 1,000 bed military hospital.			203
Paul	1964	Estimates of combustible waste generation had risen from 8 lb/day/patient "a few years ago," to 10 lb/day/patient, or more.			236

TABLE 7 (continued)

Source	Year Presented	Contribution of Solid Waste	Reference
Farr and Healy (discussing British Standards)	1965	Recommended values, in absence of specific data, were 5 lb/day/bed*, or 0.5 cu ft/day/bed*. A range was reported of 0.1 to 0.93 cu ft/day/bed*.	94
Falick	1965	Estimated increase from approximately 6 lb/day/patient in 1955 to 13 lb/day/patient in 1975.	93
Holbrook	1966	19 lb/day/patient at a teaching hospital with 1,100 beds. (Included 8.3 lb/day/patient of garbage and noncombustibles, and 10.7 lb/day/patient of "readily burnable material.")	139
Incinerator Institute of America, Incinerator Standards	1966	Design basis for incinerators of 8 lb/day/bed*, and 6 hr/day of operation.	158
Rourke	1967	Estimated increase during preceding 10 years from 6 to 9 lb/day/patient, to 20 lb/day/patient.	256
Oviatt	1967	4.3 to 11.0 lb/day/patient found at hospitals with 200 to 725 beds.	232
Holbrook	1967	20 lb/day/patient.	201

TABLE 7 (continued)

Source	Year Presented	Contribution of Solid Waste	Reference
Syska and Hennessy, Inc., Engineers	1968	17 lb/day/patient.	279
Davis	1968	Estimated 12 lb/day/bed*.	68
Baker	1968	Mean of 12.3 lb/day/bed* found at 7 hospitals (range of 9 to 19 lb/day/bed*).	22
Groce	1968	Estimated increase in preceding 10 years from 6 to 9 lb/day/patient, to 12 to 19 lb/day/patient.	123
Jacobsen	1969	15 lb/day/bed*.	166
Syska and Hennessy, Inc., Engineers	1969	At least 10 lb/day/bed* from "general hospital buildings, excluding food service wastes and loads from auxiliary buildings". Waste contribution was expected to peak at 20 to 25 lb/day/bed*.	281
Plate, Cup, and Container Institute, Inc.	Undated. Received 1969.	Estimate of 30 lb/day/patient for one hospital, "consistent with national averages."	241

*Contributions of solid waste listed as "lb/day/bed" may be converted to "lb/day/patient" by using percent occupancy of the hospital, as follows: lb/day/patient = (100 percent occupancy)(lb/day/bed). Since nongovernmental, nonprofit hospitals have an average occupancy of 80 percent[6], the conversion factor would typically be 1.25.

increase in the amount of solid wastes generated per patient. Generally, values cited have ranged from 7 lbs per day per patient, approximately 20 years ago, to 10 lbs or more per day per patient in recent years. Individual hospitals undoubtedly have shown values much higher and much lower than these.[35]

Types of Hospital Solid Waste. The literature contained little data on the composition of solid wastes from hospitals. The data that were found are summarized below:

Waste Composition (Percent)

Year	Garbage	Rubbish	Other	Reference
1937	40 to 50	50 to 60	-	231
1949	47 to 50	50 to 53	-	227
1955	38	62	-	160
1956	46	52	2	11
1966	44 percent garbage and non-combustibles, and 56 percent "readily burnable material"			139
1975 (projection)	10	90	-	93

These data show little evidence of a trend. The projection that the garbage content of the solid waste will decrease so greatly is consistent with the current trend toward the use of foods which are prepared and even portioned outside the hospital.

Sources of Hospital Solid Waste. Table 8 lists waste materials from various sources within the hospital, as summarized from articles by Holbrook[140] and Oviatt.[232] While

TABLE 8

SOURCES AND TYPES OF SOLID WASTE GENERATED WITHIN THE HOSPITAL, AS ADAPTED FROM TWO AUTHORS

Holbrook[140]		Oviatt[232]	
Source	Types of Solid Waste	Source	Types of Solid Waste
"Offices"	Combustible waste.	Administration	"Paper goods."
"Nursing floors and stations"	Combustible, pathological, and noncombustible waste.	Nurses' stations	"Ampules; disposable needles and syringes; paper goods."
		Isolation rooms	"Paper goods containing nasal and sputum discharges; dressings and bandages; disposable masks; leftover food; disposable salt and pepper shakers, etc."
"Laboratory and X-ray"	Combustible, pathological, and noncombustible waste.	"Laboratory, morgue, pathology, and autopsy rooms"	"Contaminated glassware, including pipettes, petri dishes, specimen containers, and specimen slides; body tissues; organs; bones."

TABLE 8 (continued)

Holbrook[140]		Oviatt[232]	
Source	Types of Solid Waste	Source	Types of Solid Waste
Surgery	Combustible, pathological, and noncombustible waste.	"Emergency and surgical departments, including patient rooms"	"Soiled dressings; sponges; body tissues, including amputations; waste ampules; disposable masks; needles and syringes; drapes; casts; disposable blood lancets; disposable emesis basins; Levine tubes; catheters; drainage sets; colostomy bags; underpads; surgical gloves; etc."
Emergency	Combustible, pathological, and noncombustible waste.		
"Receiving and stores"	Combustible and noncombustible waste.	"Service areas"	"Cartons; crates; packing materials; paper goods; metal containers, including food containers, solution bottles, and pharmaceutical bottles; wastes from public and patient rooms, including paper goods, flowers, etc; waste food materials from the central and floor kitchens; wastes from x-ray; discarded furniture; rags; etc."

TABLE 8 (continued)

Holbrook[140]		Oviatt[232]	
Source	Types of Solid Waste	Source	Types of Solid Waste
Pharmacy	Wet Waste ("incompatible with sewer and difficult to burn"), and combustible and noncombustible waste.		
Central supply	Wet waste (as described above), and combustible and noncombustible waste.		
Dietary	Garbage and similar waste (suitable for grinding and discharge to sewerage system), wet waste (as described above), and combustible and noncombustible waste.		
		Obstetrical department, including patient rooms.	"Soiled dressings; sponges; placentas; waste ampules, including silver nitrate capsules; needles and syringes; disposable masks; disposable drapes; sanitary napkins; disposable blood lancets; disposable catheters and colostomy bags; disposable enema units; disposable diapers and underpads; disposable gloves; etc."

neither reference is exhaustive with respect to sources of solid waste within hospitals or types of waste from every source, each does illustrate the variety of materials included in hospital solid waste and the widespread presence of contaminated or otherwise hazardous material. Holbrook indicated that pathological waste is generated on nursing floors and stations, laboratory, surgery, emergency, and central supply. A report of a study done at the University of Minnesota indicated that contaminated waste is generated in many areas of the hospital. The report contained the following statement:[36]

> "Of significance is the discovery that such uncombustible material as glass bottles and vials, such odoriferous and contaminated materials as unwrapped ABD pads, enema tubes, and perineal pads, as well as expensive items like [such as] aluminum dishes, all find their way into a common receptacle."

Disposables and Related Items

The increase in solid waste quantities has been due in large measure to increasing utilization of single-use items, single-patient items, unit-dose and unit-serving packages, and similar items. The term "disposables" has been used to describe many such items as a group. Whitcomb (1964) commented on the increasing number of disposables which were being used at that time. He noted items made from paper and plastic, as well as certain sharp items.[304] Other disposable items are manufactured from nonwoven fabric, the use of which was considered "particularly fast-growing and wide-ranging." Most nonwoven fabrics were reported to be made from rayon fiber.[287]

A number of authors have discussed the effect of disposable items on the quantity of solid waste from hospitals, as well as on waste characteristics and disposal requirements. Holbrook, who noted an apparent marked increase in solid waste quantity at a hospital, considered that the increase was largely attributable to disposable items and related packing material.[139] Freedman[100] noted that the disposal of disposables might affect future hospital design, but judged that widespread use of disposables in the hospital was justified as a measure to minimize infection. He suggested a number of possible disposal methods, including central incineration, maceration-concentration incineration, and incineration at the point of use. Freedman suggested that dissolution of plastics in solvent might become feasible, and that disposable items might be designed such that they could be "mashed flat, macerated easily, or perhaps pressed into slugs."

Peimer and Gothelf reported on a Detroit hospital which underwent a large-scale change from reusable to disposable items. Solid waste quantity was found to increase, but collection efficiency also increased with the use of disposable receptacle liners. Disposal of the increased quantity of waste was accomplished by operating the incinerator two shifts per day.[237]

Rooen stated, "In general, administrators agree that currently there is no real problem in disposing of single use items." The administrators were of the opinion, however, that problems with disposables could arise if more such items were used.[255]

White reported on an 18-month study of more than 100 disposable items in a London Hospital. He noted the possibility of using small, multiple incinerators to dispose of solid waste at the ward or floor level.[306]

Falick attributed the "dramatic" increase in "total waste bulk per patient" to increased use of disposables. He believed that protection against the spread of infection was the major factor in the growing use of disposables, but that, "originally, disposables were used to save money." Falick also noted that the growing proportion of plastic in hospital solid waste, which was due largely to the use of disposable items, was increasing the heat potential of the waste. The heat potential of hospital solid waste was reported (1965) to be as high as 6,500 British thermal units per lb, and this was projected to increase to approximately 14,000 British thermal units per lb by 1975.[93]

Michaelsen and Vesley presented (1966) the results of a survey of the use of disposable items at 12 hospitals in the Minneapolis-St. Paul area.[207] The hospitals ranged in size from 121 to 850 beds. The following numbers of types of disposables were listed as used by certain of the hospitals:

Area of Hospital	Number of Types of Disposables
Nursing Services	126
Dietary Departments	29
Surgical and Obstetrical Areas	24
Laboratories	26
Housekeeping Departments	13
Total:	218

Some indication of the numbers of various disposable items used at individual hospitals can be obtained from the study of Baker,[22] as well as from that of Michaelsen and Vesley.[207] The following table summarizes data supplied by these workers on numbers of selected items used in a 3-month period:

Type of Disposable Item	Michaelsen and Vesley (1966)	Baker (1968)
Urinary bags	173-4,867	36,000
Face masks	125-23,950	15,000
Needles	3,437-208,250	Over 137,500
Souffle cups	10,000-358,000	Over 375,000
Diapers	3,600-103,200	86,700

Baker's data were adapted to be comparable to those based on the 3-month period used by Michaelsen and Vesley.

One finding presented by Michaelsen and Vesley was that "the feeling of 11 out of the 12 hospitals is that the use of disposable products in hospitals will definitely continue to increase in the foreseeable future, with very few reservations on this prediction."[207] Although most observers apparently believe that the use of disposable items will continue to increase, this view is not universal. Ross E. Hofmann, presenting an industrial engineering viewpoint,[138] expressed the opinion that the trend to disposables would "continue and expand" primarily in hospitals having fewer than 150 beds. Larger institutions were thought to have the "processing volume" necessary to justify the automation of the reprocessing of supplies for reuse, with large savings in cost as compared to using disposables. Hofmann wrote as follows:

> "All analysts, and a large percentage of the administrative personnel, of medium size and larger hospitals, are now convinced that one of the principal reasons for the increase in hospital operating costs in the past ten years is the unwarranted and uneconomical purchase and use of disposable supplies."

He continued with a defense of the economics of automated reprocessing systems:

> "Engineers have proven in dozens of hospitals that production techniques can and must be used, to achieve drastic cost reductions with complete safety and lack of contamination. Unit costs of the reprocessed reusable have fallen far under the cost of the disposable counterpart. It is said that, at present, only a surgical needle and an I. V. administration set can be purchased cheaper or better in disposable form. All other items can be reprocessed for as little as 10% of the cheapest disposable."

Similar sentiments were found in the report of the National Sanitation Foundation conference, "Use and Disposal of Single-Use Items in Health Care Facilities."[40] Here, such factors as increasing affluence, growing difficulty in staffing menial positions, as well as demands for increased safety, comfort, and convenience, were all placed ahead of economics as factors in the increasing use of disposables. Discussion at this conference also indicated that particular problems in disposal are being created by those single-use items and packaging made from combinations of several basic materials, including glass, paper, plastics, metals, and textiles. Combination of materials can make incineration more difficult, and render recovery of and of the component materials uneconomical.

Storage and Transfer of Solid Waste at the Hospital

Storage of Solid Waste. Considering storage of solid wastes, an early reference (1945) described the introduction of fabric bag receptacle liners. The fabric bags were reported to lessen noise and save time in collecting solid waste.[43] One author suggested that fabric liners should be laundered monthly, or more often if soiled.[297] However, Wickens (1964) recommended laundering after each use.[307]

The use of disposable receptacle liners apparently brought a substantial advance in the sanitation of solid waste handling at hospitals. Introduction of the liners was gradual, and, at the time of the American Public Health Association report (1956), only a few of the hospitals considered were using disposable liners.[11]

Both paper and plastic bags have been used as liners for solid waste receptacles. A number of authors, particularly in earlier references, recommended the use of disposable bags for contaminated materials.[41, 150, 188, 270, 311] However, paper bags have been used for general refuse for a considerable time.[56] Paper bags used for solid wastes today may offer wet strength,[235] paper specially formulated to withstand rough handling,[316] treatment with a bacteriostatic agent, a range of colors for coding according to type of waste, and capability for use with either specialized bag holders or receptacles.[99, 316]

The National Institutes of Health studied the use of paper bags for solid wastes generated in their facilities. Advantages noted included less exposure of personnel to waste, reduced noise, reduced muscle strain since heavy receptacles were not lifted, and lessened need for the washing of receptacles. Problems noted during the 6 months of study included tearing of bags, leakage, breaking of a few bags, resulting in odor, and several instances of employees receiving puncture wounds from disposable needles penetrating the bags.[63]

The use of plastic bag receptacle liners has also found a significant place in American hospital practice,[113, 124, 126, 144, 189, 214, 261] and in that of other nations.[66, 135, 225] Saving in time of custodial personnel has been particularly noted with plastic bags.[237, 293] Such savings can be seen in the following comparison of total time attributable to emptying a receptacle with and without a disposable liner:[293]

Operation	Personnel Time (Minutes:Seconds) Disposable Liners Used	Personnel Time (Minutes:Seconds) Disposable Liners Not Used
"Clean out contents"	--	1:50
"Prepare wash solution"	0:16	1:54
"Handling and washing"	1:25	9:53
	1:41	12:57

Lessened time for washing when disposable bags are used reflects lessened frequency of this operation. Other advantages of plastic bags for solid wastes are reported to include reduced noise, less wear on receptacles, less need for receptacle washing,[293] less leaking of moisture, and exclusion of insects. Many of the advantages of plastic bags also apply to paper bags. However, one hospital reported that, since plastic liners sometimes tear or slip down from the top of receptacles, it was able to save $14,000 per year in receptacle cleaning costs with paper bags and specialized holders.[99] Enclosure in plastic bags is probably particularly appropriate for waste which may disseminate contamination into the air, including waste which might be contaminated with pathogens or radioisotopes.

The American Public Health Association report of 1956 contained considerable detail regarding receptacles.[11] Steel cans of approximately 32 gallon capacity were most commonly used for kitchen garbage, metal receptacles of three to five gallon capacity were used in most patient rooms and offices, and metal receptacles of a wide range of sizes were used in treatment and examination rooms. Galvanized steel cans and miscellaneous other receptacles were used for noncombustibles, and small galvanized steel cans or stainless steel receptacles were most frequently used for surgery and autopsy waste.

Plastic receptacles have also come into widespread use. Advantages claimed for plastic receptacles include exclusion of insects, freedom from denting and rusting, and easy cleaning. Wickens considered that plastic receptacles were preferred for most refuse because of ease in cleaning and handling and freedom from corrosion.[307] Regarding solid waste receptacles, the National Fire Protection Association indicated that construction should be noncombustible.[220] A specialized "flame-tamer" receptacle cover has been designed to smother fires in receptacles by directing emissions downward.[302]

A number of writers have commented on the need for cleaning receptacles, especially before disposable liners were used widely. Butters (1953) noted the need for steam cleaning of garbage cans.[44] Deming (1958) stated that cans should be cleaned with hot water or steam after each use,[72] Negus (1959) recommended that cans be "thoroughly cleaned" and disinfected after emptying,[223] and Drake (1961) indicated that receptacles should be sanitized after each emptying.[83] A hospital engineers' forum in 1967 recognized the need for steam cleaning of receptacles.[149] Other problems with solid waste receptacles have included shortness of useful life, approximately two years for metal cans,[2] and bending and denting of metal, permitting entrance of insects.[262]

Collection of Solid Waste Within the Hospital. Hospitals most frequently have systems of manual solid waste collection, primarily using pushcarts.[232] However, the report of a recent National Sanitation Foundation conference stated that "since cart systems for collection and conveying of solid wastes within the institution are obsolete, alternative methods should be explored."[40]

Sister M. Clarisse presented (1958) a sample policy on waste handling. This policy included twice daily solid waste collection from patient care areas, and once daily collection from offices. Personnel other than those in the housekeeping department were considered responsible for the collection of waste from operating rooms, laboratories, and the morgue.[54] Drake noted (1961) that hospital solid waste was commonly collected from points of generation only two or three times per day, and that this necessitated designing solid waste facilities for peak loads.[83]

The literature includes a number of examples of solid waste collection systems. At one large hospital, waste was stored (1945) in painted, empty oil drums, which were mounted on castors. The drums, when filled, were manually pushed to central collection points, without need for the waste to be transferred.[127] At another hospital, solid waste was collected using a cart which carried empty receptacles to be exchanged for full ones.[44] A third method of solid waste collection was used at a hospital in Georgia. Here, waste was stored in 55 gallon covered soap drums, lined with disposable plastic bags. Bags were closed and carried away using a covered metal cart.[230]

Bond and Michaelsen reported on the handling of solid waste at two Minneapolis hospitals. Their comments give an interesting insight into hospital solid waste handling[36]:

> "The complexity of the waste handling operation, even in a relatively small hospital, became obvious. The wastes are handled by patients, doctors, nurses, housekeeping maids, janitors, laundry workers, visitors, technicians, orderlies and aides. They are stored in wastebaskets, GI cans, laundry hampers, carts, buckets, and on the floor. Some are wrapped and some are loose. Some wastes are wet, some bloody, some heavily contaminated, some fairly clean. Some wastes are stored in the patients' rooms, some in utility areas, some at the bottom of chutes and some in incinerator rooms. The wastes traverse the hospital in every horizontal direction and vertically. Some are moved by gravity and some by elevator. The personnel handling wastes have nearly unlimited access to all areas of the hospital. Above all, perhaps, is the phenomenon of continuous generation of waste throughout a 24-hour period and sporadic collection of the waste at fixed intervals during the day shift."

Numerous problems and remedies have been noted with regard to the conveyance of solid waste through the hospital. The American Public Health Association recommended disposable receptacle liners as an important means for reducing the hazard of infection of personnel handling solid waste.[11] Drake suggested that disposable liners would minimize dispersal of organisms, apparently considering that such dispersal would occur if wastes were transferred from one receptacle to another.[83] Oviatt observed that a cart system provided "many chances for contamination of the environment and for accidents." The American Hospital Association suggested (1952) that wastes be covered when collected.[8] Sister M. Clarisse specified that carts of solid waste be routed away from food preparation areas. Recognizing that handling of solid waste involved safety hazards for personnel, she suggested that personnel wear gloves.[54] Carts should be "cleaned routinely, as frequently as facilities permit, without waiting for accumulation of clearly visible gross soil."[26]

Gravity Chutes. Falick described gravity chutes as the simplest means of vertical transfer of solid wastes.[93] The advantages of chutes in conveying solid waste have been widely recognized, despite the existence of problems. Oviatt observed that "from a transport viewpoint, the gravity chute has distinct advantages over the common cart system in that it eliminates many of the handling and labor problems of the cart system."[232] Hughes noted that solid waste chutes save labor.[153] Faulkner referred to chutes as "great conveniences",[95] and Jones wrote of the high efficiency of chutes in refuse conveyance.[168] The

American Hospital Association, in a publication on infection control, described solid waste chutes as "particularly convenient for quick disposal."[7] The report of the National Sanitation Foundation Conference, referred to earlier, indicated that "gravity chutes have substantial materials handling advantages."[40] Gaulin also referred to chutes as efficient.[110]

The advantages of chutes for conveyance of solid wastes are balanced by a substantial array of problems. The problems have apparently caused a reaction against the use of solid waste chutes in hospitals. Oviatt observed that chutes had "fallen into considerable disfavor."[232] A survey of 98 solid waste chutes in Pennsylvania showed that "26 had been discontinued, and 32 were being used on an exceedingly controlled and limited basis."[273] Some references have even indicated that chutes are not suitable for hospitals.[189, 246]

Many references have called attention to the problems which occur in the use of chutes and have noted solutions. The National Sanitation Foundation Conference report referred to "potential of environmental contamination and fire hazard."[40] Drake listed problems with solid waste chutes as blocking, difficulty in cleaning, spills in loading, and dispersal of organisms.[83] Oviatt noted fire hazard and microbiological contamination.[232] Other writers have also reported fire in solid waste chutes to be a significant hazard,[95, 110, 153, 273] with one reference noting the danger of fires from accumulations of solid waste at the discharge of the chute.

A number of references gave details as to the environmental health problems occurring with hospital solid waste chutes. Cranford, in studies at a large medical center, concluded with the following description of a solid waste chute: "unsanitary in use, emits malodorous air, is continually inoperative due to stoppage, and harbors Staphylococcus aureus organisms."[65] While some references noted the harboring of vermin,[110, 246] and difficulties in cleaning,[110] most discussion of environmental health problems with chutes concerned the dissemination of microbiological agents into the air and the resultant contamination of various areas of the hospital. Bond and Michaelsen reported on the use of tracer organisms. They demonstrated potential for vertical airborne conveyance of bacteria via a chute and spread into adjoining areas.[36]

Hurst, et al. found exhaust air from hospital laundry and refuse chutes to contain "considerable numbers of coagulase-positive penicillin-resistant staphylococci," which they considered capable of contaminating hospital corridors. Noting the heavily contaminated nature of some wastes conveyed through the chute, they suggested that "chute staphylococci may well have been responsible for some of the infections which were hospital acquired."[154]

Top commented on the mechanism by which microbiological contamination might be disseminated, observing that chutes "provide a piston effect, and not only force contaminated air down the shaft, but may force bacteria-laden air horizontally into nursing stations or other areas of the hospital."[289] Other authors have also commented on problems with solid waste chutes.[7, 95, 115, 273, 295, 300]

The various suggestions and recommendations for avoiding problems with solid waste chutes at hospitals may be divided into three categories. These are (1) design and construction of chutes, (2) characteristics, treatment, and enclosure of solid waste sent to chutes, and (3) operation of chutes.

Considering design and construction, the National Fire Protection Association presented design specifications for solid waste chutes. Chute openings were to be self-closing, and to be located in a room or compartment with walls, floor, and ceiling assemblies having a fire resistance rating of at least one hour, and fire doors suitable for Class B openings. The chute was to discharge to a bin or room separated by fire walls and fire doors, and numerous other specifications were made.[220] Suggestions on the design and construction of solid waste chutes to minimize fire hazard were found in other references, and included automatic sprinklers at the top of the chute and in chute discharge rooms,[95, 236] fire resistant construction,[95, 236] charging waste in fireproof rooms,[110, 236] and other suggestions.[153, 154, 273] In order to avoid blocking, chutes should have an adequately large cross section, with a diameter of 30 in. considered satisfactory.[93] Construction should also avoid sharp bends, where blocks would be likely to occur.[197]

Measures noted for avoiding contamination of the air from chutes have included double charging doors,[93] such as the airlock design used at an English hospital,[66] and proper venting of the chute.[93, 95, 153, 197] Michaelsen showed a reduction in air-borne contamination by providing mechanical exhaust for a chute.[205] Recommendations for preventing bags of waste from breaking have included several methods intended to slow the fall of waste in the chutes.[64, 203] To facilitate cleaning, one hospital used seamless stainless steel for the chute.[145] Other measures have included sprinkling heads for washing the chute,[93, 273] and various ways of designing for ease of cleaning.[197, 311]

Concerning the solid waste itself, several writers have referred to the need to exclude certain wastes,[94, 154] especially "grossly contaminated articles"[311]; to exclude certain hazardous items, such as lighted cigarettes[153]; to autoclave infectious materials before sending these to the chute[154]; and to enclose the waste in disposable bags.[7, 64, 66]

Related operational measures include use of the chute by only trained personnel,[95] regular cleaning of the chute[153] using built-in sprays, manual methods, or portable equipment, and preventing fire by avoiding blockage of the chute or accumulation of waste.[153]

Other Methods of Solid Waste Conveyance. A recent hospital consultant's report distinguished between conventional methods of conveying material in large volume and the use of more sophisticated methods.[198] Conventional systems have been considered to include fork trucks, tractor trains, towlines, elevators, and other similar systems. Several of the sophisticated, or more recently developed methods of solid waste collection within the hospital, are discussed in the following paragraphs. Included are pulping systems, pneumatic tube systems, monorail systems, and self-propelled cart systems.

Pulping Systems. Pulping is a method of solid waste conveyance which has received considerable discussion in the literature. Davis described a pulping system in detail.[68] The grinding unit "operates much like a large garbage grinder." The ground material "is mixed with chemically treated water to control both odors and contamination." The slurry is then conveyed by pipe to a terminal, where water is extracted, leaving "a semi-dry homogeneous pulp which has been reduced to 40 or 50 per cent of its original volume." The water removed at the terminal is recycled to the grinding unit. Davis indicated that the system is not intended for pathological waste. The pulp might be hauled away, and savings in cost were claimed on the basis of reducing the manual labor otherwise required for on-site solid waste handling. Davis suggested, however, that the homogeneous nature of pulp might make it particularly suitable for automatic charging to an incinerator. This would permit residence time in the combustion chamber to be increased, allow a smaller incinerator, and aid in maximizing combustion efficiency. In addition, claims were made for savings in cost compared with the alternative of hauling away the pulp. Others have noted the possibility of incineration following pulping.[97, 156, 281]

There have been reports of the successful operation of pulping systems, both in hospitals and in other settings.[129, 137, 148, 214, 248, 252, 260] Nevertheless, suggestions and reports of problems with pulping systems have been reported. One hospital found (1965) a pulping system "not very satisfactory" since "refuse had to be sorted to keep the machine working right, and besides, this did not solve any of the problems involved in interior trash collection."[234] Oviatt suggested the possibility of a "hazardous aerosal" at pulping devices, and noted that the weight of the waste is increased in pulping.

He also observed that "there is hesitancy in some areas of the country for reception of the pulp to landfills because of the possibility of leaching contaminants into the surrounding soil and subsurface water systems."[232] Holbrook listed the limitations of pulping systems as odor from the dewatered pulp necessitating prompt removal, difficulty in incineration due to moisture content, possibility of the grinding unit clogging when plastics were pulped, possible contamination from recycled water, increase in weight due to pulping, and necessity of providing separate conveyance for material which could not be pulped.[140] Foltz (1969) listed disadvantages of pulping systems as a limited ability to handle plastics, high cost of equipment, and high maintenance cost.[97] Nevertheless, a National Sanitation Foundation Conference report recognized pulping systems as "showing much promise", and noted that "research for further improvement of such methodology is proceeding."[40]

Pneumatic Tube Systems. Pneumatic tube systems, including vacuum installations, were recognized by a National Sanitation Foundation Conference as "giving promise of more effective handling with minimizing of associated problems."[40] Oviatt (1967) indicated that pneumatic chutes were being installed in several hospitals then under construction.[232] He considered that the systems reduced "handling problems and labor costs within the facility", and also had the advantages of removing waste directly from the patient care environment and being capable of both horizontal and vertical movement.

Holbrook (1968) suggested that pneumatic chutes possessed certain disadvantages, noting that the blowers for such systems required "considerable horsepower," and presented engineering problems with respect to noise control.[140] Falick stated that pneumatic tube systems for solid wastes should have "double door interlocks, floor loading, and negative air pressure throughout."[93] Syska and Hennessy, Inc., Engineers, indicated that pneumatic chutes could be made to rise over "structural or mechanical obstructions," thus facilitating installation in existing buildings.[281] They also suggested that a pneumatic tube system could be designed to serve the discharges of existing gravity chutes.[280]

Monorail Systems. Monorail systems of several suppliers were described in the literature. One system, developed in conjunction with a Stockholm firm, utilizes a "powerized" overhead rail system to deliver supplies to selected points. Supplies are unloaded at the appropriate points, and soiled materials are returned via a separate monorail shaft.[216] This system was scheduled (1965) for installation in four hospitals in the United States, and one in Sweden.[224]

A second monorail system was developed in Switzerland.[102] As with the preceding, this system was claimed to provide savings in cost by reducing manpower requirements, reducing supply inventories, and eliminating special purpose materials handling systems.

Self-propelled Cart Systems. A self-propelled cart system was offered by at least one supplier, with vehicles electronically guided and capable of horizontal and vertical movement. Specialized horizontal and vertical shafts were noted, as for the monorail systems.[216] Syska and Hennessy described the carts used in this system as battery driven, self-propelled, wheeled, having the destination of each unit selected before being dispatched, and guided by electrical impulses from wiring in the floor.[280]

Other Systems. The systems for conveying solid wastes which have been discussed thus far are not the only ones available. Syska and Hennessy described conveyor systems and automatic dumbwaiters,[280] and Greenberg also noted the same.[121] Letourneau described an automatic tote box conveyor, then in use at an Ohio hospital.[184] An English hospital utilizes an endless "ladder" of slings for receiving bags of laundry or solid waste.[21] The Veterans Administration was installing (1964) an automated system of supply in two hospitals, this consisting in each instance of "almost a mile of horizontal and vertical conveyors which connect every nursing unit with every principal department."[69]

Solid Waste Treatment and Disposal at the Hospital

Incineration. Incineration has received considerable discussion in the literature as a means of handling hospital solid wastes. It is important to understand that incineration does not provide complete disposal of solid waste, since (1) certain solid waste materials are essentially unchanged in ordinary incineration, (2) a residue will remain generally from the incineration process, and (3) certain waste, such as noncombustibles, is usually separated and disposed of in other ways.

Olson described hospital incinerators as including chimney-feed types, now usually referred to as flue-fed incinerators, and direct-fired incinerators, or destructors.[227] Deming used (1958) a more elaborate classification, dividing hospital incinerators into flue-fed units, natural draft units, and high-temperature units.[72] The types of incinerators mentioned by Deming are discussed in the following paragraphs.

Flue-fed Incinerators. Flue-fed incinerators were described as convenient, but as usually operated with extreme peaks in the rate of charging of solid wastes. This interferes with combustion and can also cause nuisance by releasing smoke through air intakes.[227] Black described flue-fed incinerators as "obsolete," and as presenting problems in operation. He considered that flue-fed incinerators possessed "serious limitations on handling high moisture wastes."[26] An American Public Works Association publication stated that "flue-fed incinerators should never be installed in a hospital."[12] However, a survey reported by Sterling (1960) revealed that 71 percent of the air pollution control officers replying to a questionnaire considered flue-fed incinerators acceptable for hospitals.[276]

Natural Draft Incinerators. Natural draft incinerators were considered unsuitable for waste with high moisture, and, as with flue-fed units, incapable of properly handling certain pathological or laboratory wastes.[72] Nevertheless, such units were judged to be an improvement over flue-fed incinerators.[26]

High-temperature Incinerators. Heavy-duty, high-temperature incinerators were considered suitable for pathological wastes and other materials which are difficult to burn.[72] Air pollution requirements are increasingly requiring installation of this type of incinerator for most hospital waste, although such incinerators were previously used mainly for dietary and pathological waste.[181] Black declared that "the high-temperature type of incinerator of either grate or solid hearth construction, with drying shelves for wet wastes and an auxiliary heating unit to insure temperatures of 1200 to 1800 F is the unit of choice."[26]

Another classification scheme for incinerators has been presented by the Incinerator Institute of America. This classification, which specifies the wastes suitable for each class of incinerator is shown in Table 9.[158]

There has been widespread comment regarding the desirability of incineration for hospital solid wastes. Drake called incineration the most acceptable method,[83] and MacInnes and Palmer considered it the most feasible method available to an institution.[197] Negus described incineration as "the best method for disposal" of infectious waste,[223] and Letourneau judged that the disposal of hospital solid waste should be by incineration.[189] Syska and Hennessy referred to incineration as the most promising future disposal method.[282] Wiley stated that incineration "may be the best means of providing sanitary disposal" of hospital solid waste and certain other materials.[309] Hope suggested that incineration of solid waste generally provided the most satisfactory disposal at hospitals.[141] Briosi considered incineration at the hospital as desirable in that it avoided bringing hospital solid waste into the community.[39]

A few writers indicated strong feelings regarding the need for incineration at hospitals. Goodrich (1901) said that, "It is scarcely necessary to point out that this [hospital solid

TABLE 9

CLASSIFICATION OF INCINERATORS PRESENTED BY THE INCINERATOR INSTITUTE OF AMERICA*

Classification of Incinerators	
Class I:	Portable, packaged, completely assembled, direct fed incinerators, having not over 5 cu ft storage capacity, or 25 lbs per hour burning rate, suitable for Type 2 Waste.
Class IA:	Portable, packaged or job assembled, direct fed incinerators 5 cu ft to 15 cu ft primary chamber volume; or a burning rate of 25 lbs per hour up to, but not including 100 lbs per hour of Type 0, Type 1, or Type 2 Waste; or a burning rate of 25 lbs per hour up to, but not including, 75 lbs per hour of Type 3 Waste.
Class II:	Flue-fed, single chamber incinerators with more than 2 sq ft burning area, suitable for Type 2 Waste. This type of incinerator is served by one vertical flue functioning both as a chute for charging waste and to carry the products of combustion to atmosphere. This type of incinerator installed in apartment houses or multiple dwellings not more than five stories high.
Class IIA:	Chute-fed multiple chamber incinerators, with more than 2 sq ft burning area, suitable for Type 1 or Type 2 Waste. (Not recommended for industrial wastes.) This type of incinerator is served by a vertical chute for charging wastes from two or more floors above the incinerator and a separate flue for carrying the products of combustion to atmosphere.
Class III:	Direct fed incinerators with a burning rate of 100 lbs per hour and over, suitable for Type 0, Type 1 or Type 2 Waste.
Class IV:	Direct fed incinerators with a burning rate of 75 lbs per hour or over, suitable for Type 3 Waste.

TABLE 9 (continued)

Class V:	Municipal incinerators suitable for Type 0, Type 1, Type 2, or Type 3 Wastes, or a combination of all four wastes, and are rated in tons per hour or tons per 24 hours.
Class VI:	Crematory and pathological incinerators, suitable for Type 4 Waste.
Class VII:	Incinerators designed for specific by-product wastes, Type 5 or Type 6.

Classification of Wastes

Type 0:	Trash, a mixture of highly combustible waste such as paper, cardboard, cartons, wood boxes, and combustible floor sweepings, from commercial and industrial activities. The mixtures contain up to 10 percent by weight of plastic bags, coated paper, laminated paper, treated corrugated cardboard, oily rags and plastic or rubber scraps. This type of waste contains 10 percent moisture, 5 percent incombustible solids and has a heating value of 8500 B.T.U. per lb as fired.
Type 1:	Rubbish, a mixture of combustible waste such as paper, cardboard cartons, wood scrap, foliage and combustible floor sweepings, from domestic, commercial and industrial activities. The mixture contains up to 20 percent by weight of restaurant or cafeteria waste, but contains little or no treated papers, plastic or rubber wastes. This type of waste contains 25 percent moisture, 10 percent incombustible solids and has a heating value of 6500 B.T.U. per lb as fired.
Type 2:	Refuse, consisting of an approximately even mixture of rubbish and garbage by weight. This type of waste is common to apartment and residential occupancy, consisting of up to 50

TABLE 9 (continued)

	percent moisture, 7 percent incombustible solids, and has a heating value of 4300 B.T.U. per lb as fired.
Type 3:	Garbage, consisting of animal and vegetable wastes from restaurants, cafeterias, hotels, hospitals, markets, and like installations. This type of waste contains up to 70 percent moisture, up to 5 percent incombustible solids, and has a heating value of 2500 B.T.U. per lb as fired.
Type 4:	Human and animal remains, consisting of carcasses, organs and solid organic wastes from hospitals, laboratories, abattoirs, animal pounds, and similar sources, consisting of up to 85 percent moisture, 5 percent incombustible solids, and having a heating value of 1000 B.T.U. per lb as fired.
Type 5:	By-product waste, gaseous, liquid or semi-liquid, such as tar, paints, solvents, sludge, fumes, etc., from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.
Type 6:	Solid by-product waste, such as rubber, plastics, wood waste, etc., from industrial operations. B.T.U. values must be determined by the individual materials to be destroyed.

*From I. I. A. Incinerator Standards.[158]

waste] is a collection of filthy and dangerous material and no reasonable person would for one moment suggest that any other method than cremation [incineration] should be considered."[117] Koppenhauer referred to incineration as the only safe disposal method for experimental animals.[175] The Army Medical Service School required that infectious waste be incinerated, except that burial would be permitted in an emergency.[19] Falick noted that many states required burning of pathological waste.[93] Black stated that "since incineration facilities must be provided for the disposal of infectious wastes, many institutions have built incinerators large enough to handle all their refuse."[26] Minnesota Board of Health regulations specify that, "An incinerator shall be provided to burn dressings, infectious materials and amputations."[213]

Despite widespread recognition of the need for incineration of at least certain components of hospital solid waste, there have been indications of problems with this method. Holbrook suggested (1968) that, with increasingly stringent air pollution control requirements, hospitals might have difficulty continuing to use incinerators "because of the large investment, the quality of the maintenance and personnel, and the constant load that will be required."[140] Jacobsen suggested (1969) that air pollution control requirements would prevent many hospitals from using incineration.[166] Chafee noted (1965) some return to trucking away wastes due to incinerator problems.[50] Oviatt, using more definite language, observed (1967) that "with present emphasis on control of air pollution, the use of incinerators is being discontinued."[232] Data presented by Kraus (1969) appeared to verify a trend away from incineration at hospitals. Analyzing data from a sample of 91 hospitals, Kraus found that 67 had incinerators. Of these, 16 either did not use the incinerator or used it for pathological waste only, 10 were planning to cease incineration, and 15 expected to redesign their incinerators. In 16 of the total of 25 hospitals considering abandonment or redesign of incinerators, enforcement action by air pollution control agencies was cited as an explanation. Kraus also cited the cost of incineration, stating that "costs are considerably higher than for hospitals that do not use this method of refuse disposal."[178]

Problems experienced with hospital incinerators have been numerous. The manner of operating incinerators can be a source of difficulties. Goodrich, writing in 1901, noted that the intermittent operation of hospital incinerators led to poor efficiency and tended to cause nuisance.[117] Such intermittent operation, which is quite frequently the case with hospital incinerators today, usually means that adequate combustion temperature cannot be maintained.

Differences in the characteristics of the waste charged to incinerators can be a source of problems. MacInnes and Palmer noted that extremely wet material and dry wastes were frequently burned in the same incinerator. These writers also mentioned seasonal variation in waste characteristics.[197] The change in solid waste characteristics during the course of the years has meant that older incinerators designed to burn wet materials cannot adequately burn present day hospital solid waste, which includes a larger fraction of dry material.

Larkin noted that operation by untrained persons was a problem in the use of incinerators.[181] Kraus also cited personnel factors, observing that a competent operator was required, rather than the "traditional underpaid laborer."[178]

Falick noted that plastic in disposable items could form a "sludge on incinerator grates." He suggested that this problem might be reduced by grinding the waste, and charging it to the incinerator as a more nearly homogeneous mixture.[93] Rayner observed that only "thermoplastic" materials caused such problems with incinerator grates. These plastics, when melted, can block the orifices in gas burners and cause other difficulties.[249] A related problem with hospital incinerators is accumulation of phosphorus glaze on refractory material. This results from the incineration of bones.[40]

Danger to operational staff has been mentioned occasionally as a problem with the operation of incinerators at hospitals.

Talton stated that the solvents and propellents used in aerosol cans are flammable. Compounds used in aerosol cans include propane, butane, kerosene, and others. Talton cited an instance in which an incinerator operator was blinded by an exploding aerosol can, and recommended that such containers should never be incinerated.[283] Jacobsen also mentioned exploding aerosol cans as a problem with the operation of incinerators.[166] One method of safely disposing of aerosol cans is by puncturing them using an enclosed tool.[190] Waste ether cans are a similar explosion hazard.[82] Koppenhauer, reviewing incineration at hospitals, noted the possibility that hospital solid waste might contain extremely flammable substances, such as organic solvents. He suggested various measures to protect personnel, including interlocking charging doors.[175] Black recommended that transparent face shields be used by operators of hospital incinerators.[26]

Air pollution has been recognized as an important problem resulting from incineration at hospitals. Falick briefly discussed the problem of odors, and indicated that temperatures of 1500 to 1800 F usually would prevent problems. He recognized "fly ash, unburnt particles, and offensive smelling smoke" as air pollution problems with flue-fed incinerators, and believed that "some contaminants still escape," even with improved designs. Falick predicted that communities would be requiring increasingly emission control devices on all incinerators.[93]

Talton noted that propellents used in aerosol dispenser cans form toxic and corrosive gases when heated.[283] Other components of hospital solid waste can form objectionable gases on being incinerated. Bohne described several instances of damage to vegetation, apparently due to emissions from hospital incinerators. In one instance, grass was made yellow and plants were "bleached" by the emission from an incinerator in a hospital 450 meters away. Dust taken from the flue gas at this incinerator contained 1.56 percent to 14.3 percent chlorine, when sampled at several points before emission. In another instance, damage to plant life was found in the vicinity of an incinerator used for hospital solid waste. Analysis of the incinerator emission showed the following concentrations of several pollutants:

Sample Number	Concentration (Milligrams per Cubic Meter) H_2F_2	SO_2	HCl
1	1.24	64.1	91.98
2	1.06	87.5	111.24

The hydrogen fluoride apparently resulted from combustion of plastics.[31] Popov and Yablochkin reported on a study of the gases released during the thermal degradation of polyvinyl chloride. Table 10 summarizes their data.[243] While their study did not directly consider incineration, it gives some indication of the pollutants which might be expected from, for example, low

TABLE 10

CONCENTRATIONS OF GASES RELEASED DURING THERMAL DEGRADATION OF POLYVINYL CHLORIDE*

Substance	Concentration (Milligrams per Cubic Meter)				
		100 C		20 C	40 C
	1 Hour	2 Hours	3 Hours	30 Days	30 Days
Aldehydes	0.68	1.0	1.32	0	0.64
Dibutyl phthalate	31.2	33.2	35.6	6.4	8.8
Carbon dioxide	14,080	16,000	17,600	3,520	7,920
Fatty acids	Trace	6	10	0	0
Carbon monoxide	38	40	40	30	34
Hydrocarbons	96	168	396	552	720
Vinyl chloride	152	162	164	0	0
Hydrogen chloride	8	12	20	0	0

*Adapted from data presented by Popov and Yablochkin.[243]

temperature operation of an incinerator.

A British study evaluated the products of combustion obtained by the incineration of 18 types of disposable items, including "rigid and soft plastics, aluminum foil and steel needles, paper of various kinds and cellulose and nonwoven fabrics." For most types of disposables, the study indicated that, "there is nothing objectionable about the flue gas." Another type of disposable item which contained polyvinyl chloride was found to have products of combustion which were more objectionable. It was stated that the combustion of polyvinyl chloride with 100 percent excess air would result in 4 percent hydrogen chloride (HCl) in the flue gas. This gas has a pungent odor, is poisonous, and, combined with water vapor in the flue gas, would be "highly corrosive of most metals." There have been reports of "severe corrosion" caused by the incineration of polyvinyl chloride.[249] Even if polyvinyl chloride formed only 2 percent by weight of the material charged to an incinerator, it was judged that the concentration of hydrogen chloride in the emission would be "more than enough to be offensive." The report concluded that it would be "prudent to be cautious about using disposable goods of P. V. C.," or to dispose of them other than by incineration.[155] Rayner mentioned phosgene as another possible product of combustion for polyvinyl chloride.[249]

Several references discussed the survival of pathogens in emissions from incinerators. One article noted the use of a "second flame barrier" to destroy pathogens in emissions.[85] Michaelsen (1963) suggested that escape of infectious material through the stack of an incinerator was a possibility, especially if the unit were overloaded.[206] Falick noted the need for preventing "contaminated precipitate from being carried into the atmosphere, in order to "prevent environmental hazard to the community."[93] Study of the survival of trace organisms in incinerators was reported by Barbeito and Gremillion. Spores of B. subtilis were used in the tests. When the spores were mixed with solid waste, temperatures required to kill the spores were 700 F for air in the incinerator firebox and 385 F for the firebrick. The destruction of organisms was considered to depend on residence time, as well as temperature. These workers concluded that, regarding disinfection of the emission, "the problem may be real in some special instances." Inadequate operating temperatures were judged to occur when operation was intermittent, and when moist waste was charged. Barbeito and Gremillion emphasized the need to locate incinerator stacks properly with respect to prevailing winds, air intakes, and buildings.[23]

Another report discussed survival of bacteria in the residue from four incinerators. These units, which had operating temperatures of 1700 F or higher in each case, produced residue with the following concentrations of bacteria:

Total cells: 7,100 to 44,000,000 per gram.
Heat resistant spores: 3,900 to 100,000 per gram.
Total coliforms: 5 to 15,000 per gram.
Fecal coliforms: Less than 1 to 2,400 per gram.

The report concluded that the temperatures in these incinerators, although satisfactory by usual criteria, "provide no assurance of a satisfactory operation from the standpoint of public health." The possibilities for contamination of the residue by dust and recycled quench water were recognized.[238]

Other problems with hospital incinerators were described in the literature. Koppenhauer recognized that fire safety definitely merited consideration. Combs and Craig listed high labor requirement as a disadvantage of incinerators, noting manpower requirements for operation.[57]

Numerous references included discussion of incinerator design. Temperatures of approximately 1700 F were considered necessary for burning pathological waste.[175] Specifications of the Incinerator Institute of America required that even the smallest units be constructed to operate at "intermittent internal temperatures as high as 1800 deg.F." without failure of structural parts. All incinerators used for garbage or biological material were required to be equipped with auxiliary burners. In the case of incinerators burning biological material, gas or oil burners were required to supply at least

3,000 British thermal units per lb of solid waste at rated capacity.[158] MacInnes and Palmer noted that incinerators designed for hospitals should include a drying hearth and a secondary combustion chamber.[157] The Incinerator Institute of America specified secondary combustion chambers for several classes of incinerators. Excluded from this requirement were certain incinerators with capacities of less than 100 lbs per hour and flue-fed incinerators.[158] Farr and Healy noted that British standards described natural gas as the preferable fuel for incinerators,[94] while the Incinerator Institute of America permitted gas or oil burners. If gas burners were provided, a "forced draft blower" to supply air for combustion was required in installations with capacities of voer 400,000 British thermal units per hour.[158]

Black briefly discussed washers for removal of particulate matter from incinerator emissions.[26] The Incinerator Institute of America recommended "auxiliary equipment, such as a fly ash collector, gas washer or scrubber" for installations in which low fly ash emission was required.[158] The National Fire Protection Association has published recommendations for incinerator installations. The incinerator was to be located in a room with fire-resistant walls and ceilings, and doors which were self-closing or which were automatic fire doors "suitable for class B openings." Automatic sprinklers were recommended for the incinerator room. Incinerators of commercial-industrial types were to include "effective means for arresting sparks and fly ash," unless the stack was provided with an approved spark arrester.[220]

Rayner discussed the effect on incinerator design of large amounts of plastic being present in solid waste. Design in this case should provide for the flame of the burner to be directed downward from above the waste, and air inlets should also be elevated above the waste. The "ash-box door" would require a tight seal "in order to forestall the difficulties caused by the melt" of thermoplastic material. Presence of hydrogen chloride in the emission would require protection of metalwork by "refractory materials such as brick or specially developed plastic," which could withstand the temperature and corrosion. Noting the possible presence of phosgene in the incinerator's emission, Rayner suggested using a tall stack or some method of removal.[249]

There have been a few references to improvements in the design of incinerators for hospital use. Leibman noted a trend toward the use of waste shredding with incinerators. By reducing the solid waste to "controlled dimensions," charging could become "automatic, uniform and dependable," leading to "vastly" increased combustion efficiency. In addition, safety would be enhanced by the dispersion of highly flammable and explosive waste.[183] Weintraub, Orning, and Schwartz reported incineration studies with simulated laboratory or hospital waste. They found that tangential air flow tended to reduce the concentration of particulate material in the emission.[303] Other improvements in design have also been suggested.

Proper operation is important in the incineration of hospital solid waste. One reference provided an operation guide for hospital incinerators. The necessity for daily cleaning and adequate lubrication was emphasized.[199] Koppenhauer presented a number of suggestions for routine operation of incinerators, including cleaning grates and removing ashes daily, preventing noncombustibles from entering the incinerator, avoiding overloading the incinerator, keeping burning materials loose and exposed to the air, being certain the air supply is adequate to prevent smoke, keeping draft passages clear, operating dampers weekly, learning what may be burned without overheating the incinerator, and ventilating the combustion chamber before igniting waste to avoid explosion from accumulated gas.[175]

Utilization of Heat from Incineration. The possibility of utilizing the heat generated in incinerators has received considerable comment. Goodrich in 1901 mentioned the possibility of using hospital incinerators for heating water.[117] Overton noted in 1937 that recovery of heat from incineration at hospitals had attractive features.[231] MacInnes and Palmer, describing (1946) British practice, speculated that, in exceptional cases, an institution might profitably utilize a portion of the heat generated in incineration. It has been unusual for such heat actually to be used, since other sources of heat invariably are provided, and since the generation of solid waste is often erratic.[197]

Falick stated that recovering heat from the incineration of solid wastes is becoming more profitable "as wider use of plastics increases its energy potential." He estimated that a 250-bed hospital might save $750 to $1,000 per year by utilizing such waste heat.[93] Holbrook wrote that the utilization of heat from incineration would be more likely in the future, although it was not clear that he had specific reference to the hospital setting.[140] A British hospital journal reported (1960) on an incinerator installation which recovered energy for space heating. Refuse could be burned to provide up to 500,000 British thermal units per hour.[266]

Small Incinerators for Decentralized Disposal. Small incinerators to serve, for example, individual floors and wards, have received most attention in British practice. MacInnes and Palmer mentioned (1946) a tendency in Britain to install small incinerators close to the areas of waste generation in order to prevent accumulation of waste.[197] White reported on British hospital studies which revealed that it was "helpful" for each ward to have its own incinerator "in order to destroy waste as soon as it was produced."[305] Farr and Healy stated, "Investigations by the Ministry of Health and other interested organizations have resulted in a general recommendation for the installation of small incinerators in or near medical or surgical wards for the destruction of small dressings." This was considered important in minimizing the risk of spreading infection.[94] Lewis suggested that incineration in multiple small units in hospitals could reduce the hazard of disseminating bacteria, and offer savings in cost by lessening labor requirements for solid waste collection.[191] White described progress in the development of small incinerators as "gratifying", and expressed the opinion that the provision of such units at the ward or floor level was "worth considering."[306]

Grinding of Solid Waste for Discharge to Sewerage System. The removal of certain solid waste from hospitals by grinding and discharging to the sewerage system has become widespread. Units for accomplishing this are referred to as grinders or disposers. Most of the references to the hospital use of grinders have concerned food waste. A number of comments have been made regarding the advantages of grinders. Adams observed that grinders reduced the likelihood of insect or rodent infestation, and thus reduced environmental sanitation problems.[2] Reduction in odors was also recognized as an advantage, and this, as with the preceding, was associated with a lessening of the need for storage of garbage.[141, 292] Other advantages noted for grinders have included savings in labor,[228] apparently due to lessening of solid waste collection requirements, reduction in the amount of garbage sent to incinerators.[181] where combustion is difficult, and a lessening in the problem of losing silverware with food waste.[105]

The types of disposers available to hospitals include the rotating shredder variety, which is similar to units for home use, and the hammer-mill variety, usually limited to units having motors of five horsepower or more.[12, 196] Most hospital grinders are units of the rotating shredder type. Grinders are most frequently used in hospital dishwashing facilities,[196] but provision in food preparation areas has also been recommended.[110] Installation could be based either on the "point of origin" system, which would require individual units at the points of waste generation, or based on the "central" system, which would have units serving multiple points of generation.[196] The first system was described as leading to greater savings in labor[228] and better sanitation,[314] apparently due to immediate removal of waste.

In an older reference (1958), it was suggested that whether grinders were installed should depend on such factors as the cost of the institution's internal solid waste collection and the quality of the community solid waste collection system.[2]

Grinders available to hospitals vary from units with motors of a fraction of a horsepower to those with motors having five horsepower or more. Selection of units should be based on the characteristics of the material to be handled, such as size, rather than primarily on the amount of waste.[196] Tests with a standard food waste indicated capacities of 200 and 1,200 lbs per hour, for grinders with 0.5 and 1.5 horsepower, respectively.[26]

A number of comments have been made regarding the installation of grinders at hospitals. Black suggested installation "backflow prevention device."[26] MacFarlane stated (1957) that proper installation required adequate water supply, about 2.5 gallons per lb of food waste, adequate electrical supply, and sufficient space. Drain pipes should be at least two in. in diameter. The possibility of an air gap being required to protect the potable water supply was also mentioned.[196] A minimum slope of 0.25 in. per ft was recommended for drain pipes. Larger units, especially, should be bolted securely in place to minimize vibration.[45] Another reference specified water requirements as 2 to 10 gallons per minute for units with one-half to five horsepower. Often installation of a grease trap was considered necessary when a grinder was being used.[245]

Problems with the use of grinders were recognized by a number of writers. Problems at the hospital can include noise, vibration,[245] jamming of the grinder,[45] and blocking of drain lines. Proper operation, including feeding waste at a relatively constant rate and using an adequate flow of water, can lessen such problems.[292] Grinding of solid waste, as presently used, has limited applicability, and leaves combustible and noncombustible waste to be disposed of in other ways.[2] Even considering only the dietary department, certain food waste either cannot be handled by grinders, offer potential for clogging drain lines, or cause considerable noise in grinding.[12, 196]

Safety in the use of grinders has received relatively little comment in the literature. Covers are provided with certain units, some with an interlock so that operation is possible only with the cover in place. Other units have openings partially protected with rubber flaps.[12]

Little has been written regarding the maintenance requirements of grinders. One discussion of commercial and industrial units indicated that "maintenance costs are relatively low because the grinders have only a few parts that wear." Expected life was estimated as 10 to 20 years.[12]

Starkey suggested that aerosols from grinders might cause contamination of nearby clean items and areas.[271] Jopke and Hass reported on studies of aerosols emanating from grinders. They concluded that "disposers generate bacterial aerosols regardless of mechanical design," although the mechanical design might influence the level of contamination. They noted that "an exhaust system provided a very effective means for minimizing aerosolization."[170]

The use of grinders can cause effects on the sewage collection and disposal system. Adams estimated that provision of food waste grinders would require a 50 percent increase in septic tank capacity, and a 25 percent increase in the tile field, if disposal of sewage used such facilities.[2] The literature records an instance in which food waste grinders were installed at a Texas hospital and discharged to the hospital's activated sludge sewage treatment plant. The organic load on the treatment plant increased considerably, but operation apparently was still considered to be satisfactory.[106]

Although municipal sewers frequently can accommodate a substantial increase in suspended solids concentration of waste, it has been considered poor practice to use grinders where sewers are "inadequate or faulty."[12] One reference mentioned isolated instances of sewers being blocked due to the use of grinders at hospitals.[296] Effects at municipal sewage treatment facilities must also be considered. The large amounts of suspended solids put into the sewer system by commercial or industrial grinders would usually not be noticeable at the municipal sewage treatment plant because of dilution and the dampening of peak discharges.[12] Woodside estimated (1949) that the ground garbage from a 300-bed hospital would add no more than $50 per year to municipal sewage treatment costs.[314] However, some communities apparently have been concerned about the possibility of grinders causing added water pollution and operational difficulties at sewage treatment facilities.[90] Holbrook expressed concern about the possibility of water pollution from hospital grinders,[140] and Falick noted possible difficulties with floating materials.[93] In any event, there have been communities where use of grinders was not permitted.[90, 91]

Grinders have been used for biological waste. A California hospital utilized a heavy duty grinder to dispose of placentas and other human tissue.[257] McKenna also reported on the use of grinders for the disposal of placentas.[203] Oviatt noted research into the use of grinders for "biological waste."[232] In recent reports, the possibility of grinding other waste for discharge to sewerage systems has been discussed. The Los Angeles Department of Public Works has granted permission for the installation of grinders of specific suppliers to macerate and discharge certain plastic disposable items to the municipal sewer system. Consideration has been given also to using such grinders for paper and nonwoven textile waste.[192] A British publication described (1962) a device in which paper-mache disposable items could be processed for ultimate discharge to the sewerage system.[275]

Hazardous Waste

Biological Materials and Wastes Potentially Contaminated with Microbiological Agents. Important among the hospital solid waste considered hazardous is biological waste. Here the writer refers to human and animal remains, blood, microbial cultures, stool samples, sputum, and other similar materials. Included in biological waste are certain materials from such hospital areas as maternity, surgery, morgue, and laboratories.

Certain biological materials are hazardous particularly because of contamination with pathogens. Sloan, discussing autopsy procedure (1942), cited tubercular lungs as possessing particular hazard because of the possibility of disseminating pathogens into the air.[263] Bogen found that morgue employees at one general hospital had 10 times the incidence of tuberculosis as other hospital staff members.[29] Carl Walter suggested that blood, pus, and spittle, as well as such potentially contaminated materials as casts and dressings, could contaminate the air with microbiological agents.[299] Considering the laboratory, the American Hospital Association identified as particularly hazardous the organism *Mycobacterium tuberculosis*; bacteria of the pasteurella, brucella, and psittacosis groups; and certain viruses. Referring mainly to the safety of laboratory personnel, they recommended that arrangements be made for "safe disposal of animals, their excreta, and other contaminated material, and for dust control."[7] Letourneau considered discarded casts, bandages, and other wastes to be "important vectors [vehicles] in spreading disease."[187]

Proper handling of potentially contaminated waste is important. Oviatt considered biological wastes to be of particular concern, since such materials can be "a direct source of infection to persons coming into contact with them if they are improperly handled."[232] An important need in the handling of such waste is prompt enclosure. Letourneau mentioned use of a waxed paper bag and a closed container.[188] The National Institutes of Health placed all waste presumed contaminated in disposable bags which were securely closed and identified as hazardous by a red tag.[221] Nahmias and Eickhoff stated, "The disposition of heavily contaminated materials such as dressings, wound drainage and sputum in sealed containers is part of modern hospital housekeeping."[219] The American Hospital Association noted the possibility of survival of pathogens such as staphylococci and Mycobacterium tuberculosis. They suggested that contaminated waste "can be satisfactorily handled using a waxed or plastic waste bag." It was noted that this "avoids air contamination when wastes are emptied," and also prevents contamination of the receptacle.[7]

Negus described (1959) the special handling required for contaminated waste, emphasizing the importance of minimizing handling. He suggested disinfecting larger items before disposal. Another suggestion was that contaminated items of waste be immediately sealed in a waxed paper bag, and placed either in a larger, marked bag, or in a marked, lined, covered metal container used only for such wastes.[223] However, bacteriological sampling reported by McKenna showed no contamination of an elevator used to transport refuse in a certain hospital.[203] The need to refrigerate some biological waste, such as animal carcasses, is readily apparent.[313] Negus suggested that personnel handling infectious waste should wear protective clothing. Good personal habits, such as washing hands, were also considered important. Negus judged that, if practical, one properly trained person should be responsible for collection and disposal of all infectious waste.[223]

Of the various methods of disposing of biological materials, incineration and grinding with discharge to the severage system have already been discussed.[203, 257] Incineration appeared to be the preferred method.[12, 72, 223] One author suggested that use of incineration lessened the need for special handling of biological materials, although it is unlikely that special handling could be eliminated.[161] Biological materials may be difficult to incinerate since animal carcasses, for example, were reported to contain typically 75 percent water.[310] While the amount of biological waste generated at hospitals is usually small, one report indicated that a certain medical center presently generates 12 cubic yds per day of animal waste and animal carcasses[198] due to extensive research on animal subjects. It has been mentioned already that higher temperatures are needed to burn certain biological materials than are necessary for most other solid waste.[175]

Radioactive Solid Waste. Radioactive solid waste is another type of potentially hazardous material generated by certain hospitals. The quantity of radioactive material requiring disposal due to hoapital utilization of radioisotopes was considered "tiny" compared with the amount of radioactive waste resulting from nuclear generation of electrical power.[78] Mawson stated (1965) that the amount of radioactive material used in unsealed sources at hospitals was small. Included, he indicated, were only a limited number of radionuclides used in diagnosis and treatment, most of which have short half-lives. Mawson mentioned iodine-131, phosphorus-32, iron-59, chromium-51, sodium-24, carbon-14, and gold-198.[200] The International Atomic Energy Agency has presented a more extensive list of radioisotopes used for medical purposes.[163] Kenny described (1956) radioactive solid wastes from hospitals as mainly contaminated glassware and tissue paper.[173] The Association of Casualty and Surety Companies indicated (1951) that radioactive wastes from research and medical treatment were mainly liquid. However, the Association also listed radioactive solid wastes from such sources as including animal carcasses, animal tissue, vegetation, and soils. It was suggested that the disposal problem was usually much less than from nuclear electrical power plants, since only relatively small amounts of radioisotopes of short half-lives were commonly used.[20] Nevertheless, concern has been expressed about the disposal of radioactive solid waste from hospitals. A British publication raised the question of whether disposal staffs at hospitals were adequately trained,[79] and a writer in an American journal expressed concern over the possibility of introducing medical isotope waste directly into the environment.[78]

Some references have noted the need for storage of radioactive solid waste to permit decay to a satisfactory level before disposal. Mawson suggested storage for long enough to permit "safe disposal by conventional means."[200] Brady made a similar suggestion.[37]

Considering receptacles for radioactive solid waste, the International Atomic Energy Agency suggested that containers with foot-operated lids were "particularly suitable for radioisotope laboratories." However, a stainless steel can having a sliding cover and a fiber drum insert was considered "less likely to spread contamination."[163] The use of plastic bags has also been mentioned as a means of avoiding the dissemination of radioisotope contamination.[200, 313]

Several references indicated that small amounts of radioactive solid waste could be disposed of by ordinary methods. Even the disposal of small quantities of medical isotope material in ordinary refuse containers could be relatively safe.[79] The International Commission of Radiological Protection commented (1964) that "lightly contaminated" solid wastes might be disposed of with other wastes, since a few microcuries would not usually be hazardous.[165]

The most common disposal method for radioactive wastes is discharge to the sewerage system.[78] This is not feasible, however, for many radioactive solid wastes. While techniques such as ocean disposal have been used in certain situations, burial and incineration are the methods of disposal most commonly suggested for hospital solid waste.[165]

The International Commission on Radiological Protection suggested that burial of radioactive waste in a municipal disposal site could be used, provided that the radioactivity was dispersed and the waste was not likely to be salvaged.[165] Paine suggested that burial of radioactive waste was a questionable matter for a hospital because of the possibility that isotopes with long half-lives might be inadvertently uncovered. Burial might be in a national disposal site.[165] Mawson observed that the many hospitals located in urban areas might find that burial of radioactive waste was impractical.[200] Paine described (1949) Atomic Energy Commission policy on the burial of radioactive waste as requiring maintenance of records on burial and periodic inspection of disposal grounds.[233] The Association of Casualty and Surety Companies indicated that burial grounds should be isolated, fenced, posted with warning signs, and monitored for radioactivity.[20] Mawson noted that disposal should be in areas located away from sources of public water supplies, and that precautions should be taken to prevent contamination of ground water.[200]

Incineration may be a practical method for disposing of medical isotope wates at many hospitals. Kenny, writing for the World Health Organization, stated (1956) that combustible radioactive waste "can be handled in the hospital incinerator."[173] A survey of institutions in the Memphis area indicated that 11 were incinerating radioactive solid waste on the premises.[130] The International Atomic Energy Agency considered incineration to be a "useful waste treatment" for radioactive solids.[163]

The hazards of incinerating radioactive waste at hospitals should be discussed. Chamberlain noted that the release of at least a small amount of radioisotope material from incinerators burning radioactive waste could not be avoided, except at excessive cost. He presented (1961) the following recommendations for permissible release of nuclides from incinerator stacks[51]:

Permissible Emission (Microcuries per Second) for Stacks of Indicated Height

	20 Meters	50 Meters	100 Meters
Argon-41	10,000	40,000	100,000
Carbon-14	30	200	800
Iodine-131	0.05	0.3	1.3

Straub commented that radioactivity released to the air during the incineration of radioactive waste usually would be small. He also cited data which indicated that the proportions of radioactive material in the residue, in the emission, and retained on the incinerator walls would vary with the radioisotope.[277] The International Atomic Energy Agency stated that the incineration of radioisotopes brought "implicit considerations of treatment or handling of stack effluents and handling and disposal of radioactively contaminated ash material."[163] The International Commission on Radiological Protection commented on the hazard involved in the removal and final disposal of residue from incinerating radioactive solid waste. Inhalation of dust contaminated with radioisotopes was considered to be the probable "limiting hazard" in handling such incinerator residue and was considered to also have significance in final disposal.[165] Mawson suggested that incinerator design should provide for decontamination if radioisotope waste was to be burned, since "all parts of the incinerator will become increasingly contaminated during use." Although he discussed emission filtration, Mawson judged that proper design and careful location of the incinerator might render such a precaution unnecessary. Mawson also noted the need to handle ash so as to avoid airborne contamination.[200]

A number of examples of incinerators designed for radioactive solid waste were found in the literature. One unit which was described included especially designed ash handling arrangements and emission washers.[85] Amolraj and Khan described the development of a specialized radioactive waste incinerator in India. The unit was provided with an air lock for charging waste, special arrangements for safe residue removal, and emission filters.[15] Later study showed that (1) wet methods of emission cleaning were undesirable, in that they generated large amounts of contaminated liquid, and (2) durable refractory material was required, since maintenance might be hazardous when the interior of the incinerator became contaminated with radioisotopes.[286] Krause, Stollberg and Mempelman reported on an incinerator designed for radioactive solid waste. The unit was constructed with smooth interior surfaces, and with provisions for emission cleansing by means of a bag filter followed by two "superfine" filters in series, and continuous monitoring of the emission for alpha-beta ratio.[179] Meissner described an electric incinerator designed for radioactive solid waste. Two fiberglass filters in series were said to remove from the emission essentially all particles as small as 0.1 mm in diameter. Emission washers were considered uneconomical.[204]

Chemical Solid Waste. Chemical waste merits consideration, although it has received little discussion in the hospital literature. One reference described a workshop on the disposal of chemical waste from laboratories. Incineration was thought to be the "prime method," since it could be applied to most organic compounds. Highly explosive or very toxic materials were considered to require careful disposal separate from other chemical wastes. The prevailing opinion at the workshop was that "numerous problems" would result if waste was disposed of in a sanitary landfill. A method for transporting waste chemicals was discussed. The waste would be placed in a disposable container and sprayed with polyurethane foam.[315]

Other Hazardous Solid Waste. Sharp waste, especially disposable needles, has been described as presenting a safety hazard at many hospitals. The survey performed by Michaelsen and Vesley confirmed that puncture wounds from disposable needles have been a problem. These investigators suggested that the disposal of such needles at dumps could cause hazard.[207] Walter noted that discarded needles and cutting edges could be dangerous, causing injury if not receiving proper handling and disposal. Infection from such injury was considered possible. He warned of the danger in salvage efforts, or in children playing in the vicinity of accumulations of waste. Walter suggested that disposable needles be broken, that the points of the needles be covered, and that collection be in containers which did not require the contents to be transferred.[301] Letourneau, noting the possibility of hospital liability for injuries caused by disposable needles in waste hauled from the hospital, suggested that such needles be incinerated.[135] Deschambeau recommended that disposable needles not be placed in ordinary waste receptacles. He cited as reasons (1) the danger of puncture wounds to solid waste collection personnel, and (2) the possibility that discarded needles and syringes might be reused. One hospital accounted for each disposable needle that was issued from stock. Disposal at this institution began with replacing the sheath on the needle and breaking by hand. Replacement needles were supplied to areas of use on a one-for-one basis when the broken needles were collected.[75]

A number of hospitals have used various containers to safely enclose used disposable needles and other sharp items. Included have been coffee cans sealed shut with tape,[74] plastic bottles from cleaning agents.[147] and plastic jars sealed with tape.[92] Specialized disposal containers for used needles are also available, as well as apparatus for disposal. Examples of such apparatus are a needle crusher[317] and a specialized oven[298]; other devices are also available.

Medications which are discarded require special consideration in hospital solid waste handling and disposal.[301] Little mention to this problem was found in the literature.

Hauling of Solid Waste from Hospitals and Disposal in the Community

Hauling of solid waste into the community almost invariably means that central storage must be provided at the hospital for the wastes collected from the various points of generation. One recently constructed British hospital was provided with a central solid waste storage room.[119] This provision is found only occasionally at American hospitals, and it is common for stored waste to be outside. This is the case in spite of a recommendation that stored waste be kept indoors until hauled away. Such indoor storage would make the waste inaccessible to children and other unauthorized persons. One hazard of improper storage is illustrated by an instance in which a boy had taken over 150 needles and syringes from solid waste receptacles at the offices of physicians and dentists.[59] Gaulin recommended that storage for waste from dietary facilities "should be in a separate area easily accessible to the outside for direct pickup of refuse."[110]

There have been suggestions in the literature that the increased use of disposable items has affected central waste storage requirements. Holbrook mentioned (1966) a need for larger waste receptacles and more commodious storage areas.[139] One hospital indicated that increased waste quantities, resulting from both expansion of the hospital and introduction of disposables, overtaxed its waste storage facilities to the extent that incineration was substituted for the hauling away of waste.[161] In contrast, another institution found that use of a bulk solid waste storage receptacle and the hauling away of waste facilitated handling the increased waste quantities resulting from use of disposables. A chute discharging to the bulk receptacle was suggested.[194]

The literature contained considerable comment regarding problems with the central storage of solid waste. One reference described problems with flies, odor, and poor appearance. The problems were increased by the heat of summer, and by periods of no solid waste collection, such as weekends.[161] McKenna observed that the lids of bulk solid waste receptacles were often left open, resulting in unsightliness and admittance of insects.[203] Kraus mentioned the problem of leakage from receptacles.[178] A Virginia report, which discussed inspections at five hospitals, indicated that the bulk solid waste storage receptacles "were all in very bad condition from a sanitation standpoint." Problems noted included need of cleaning, presence of adult flies, and lids of receptacles being left open. The report indicated that construction was such that the lids would have been difficult for personnel to close. It was judged that the receptacles would "even when empty, cause a serious fly and possible odor problems."[251]

An important innovation in the hauling of solid waste from hospitals was the development of stationary compactor systems. An Ohio hospital used a typical stationary compactor system, which included a hydraulic ram to force solid waste into a detachable container with a capacity of 40 cubic yards. The container was detached from the compaction device and hauled away for emptying, using a special type of vehicle. Emptying the container was required three times per week, and this was considered to be an improvement over the previous schedule of trucking away waste in much smaller loads. The system was reported to have eliminated an unsightly solid waste storage area.[290] Paul noted the use of such equipment in the Dallas area. The detachable containers were said to be washed and sprayed with disinfectant after each use.[236] Such cleaning was also noted in a Texas journal.[149] The Plate, Cup, and Container Institute mentioned that odor could be a problem with stationary compactor systems, depending on the type of waste involved and the frequency of emptying the receiver receptacle.[242]

Crushing at the hospital is sometimes used to reduce the volume of solid waste to be hauled away to a disposal site. This technique has been primarily used with metal cans and glass bottles.[236] Kraus found that 39.5 percent of the hospitals which he surveyed used volume reduction equipment, and 18.6 percent planned to use such equipment in the near future.[178]

It is generally the case that hospitals have at least a portion of their solid waste hauled away for disposal. The difficulty of incinerating certain waste, such as plastic items, has undoubtedly been a consideration of increasing importance for hauling away solid waste.[258] A survey of 24 hospitals (1949) ranging from 25 to 125 beds showed the following patterns of disposal[104]:

Incineration and hauling: 14
Incineration: 1
Hauling: 9

The responsibility for hauling was as follows at the various hospitals:

Municipal: 12
Farm: 6
Municipal and farm: 2
Hospital itself: 1
Private hauler: 2

A survey performed by the Memphis and Shelby County Health Department showed that kitchen garbage from 15 of 30 institutions studied was used as hog feed. Most of the institutions from which waste was being hauled utilized municipal collection, and only a few of the institutions were provided with bulk solid waste receptacle service.[130]

Kraus presented (1969) information regarding the hauling of solid waste from 91 hospitals. His data, which differ somewhat from those of earlier studies, are as follows[178]:

Hauler	Refuse	Garbage
Hospital itself	19	6
Municipal agency	7	7
Private hauler	65	25
	91	38

While all the hospitals hauled away refuse, or general solid waste, less than half had garbage hauled away. Disposal of other garbage was mainly by grinders.

Certain municipalities provide solid waste collection for hospitals at no cost. This is the case in New York City, where buildings which are exempt from taxes are provided with collection of ashes, refuse, and garbage by the City Sanitation Department.[198] Other communities have restrictions against hospital solid waste, requiring, for example, precautions with waste which might be contaminated with pathogens. One reference suggested that municipal or private hauling of solid waste from hospitals should be used only for noncontaminated waste.[83] The adequacy of sanitation is related to frequency of hauling. Koren discussed an instance in which a sanitarian found it necessary to recommend an increased hauling frequency at a Pennsylvania hospital.[177]

Advantages and disadvantages of hauling solid waste from hospitals have been noted in the literature. Holbrook suggested (1967) that hauling away solid waste could enhance satisfactory disposal, but that cost might be high if the disposal site were distant from the hospital.[201] However, Kraus indicated that hospitals which relied primarily on the hauling away of solid waste, rather than on incineration at the hospital, usually had much lower total costs for solid waste disposal. Data were not sufficient to determine whether equipment for reducing waste volume lessened the overall disposal cost, except that stationary compactors were apparently less expensive than alternative systems in certain situations.[178] Holbrook noted that hauling could not generally be used for all hospital solid waste, since specialized disposal of pathological waste, for example, would be required.[140] Foltz considered that the hauling away of waste had the advantage of lessening air pollution from the hospital.[97] Davis claimed that the increased quantities of solid waste made hauling unsatisfactory, with cost an important problem.[68] No data were provided to support this contention.

The hazard of microbiological contamination of solid waste hauled from hospitals received early attention, for in 1908 Morse wrote as follows[217]:

> "Instances are on record where the employees of the street cleaning service have contracted disease resulting in death from exposure to infected [contaminated] matter during its removal by the city carts from the public institutions."

Taylor described (1951) the disposal of garbage from a state hospital at a hog farm, with the resulting pork and lard being used at the hospital. Wastes which could not be used at the hog farm were sent to a dump.[285] The Veterans Administration was reported to specify a minimum of 1 ft of cover material where waste from tuberculosis patients was buried, and also to require posting of the disposal area.[265] Negus indicated that a sanitary landfill could be satisfactory for noncombustibles, but suggested the use of lime as a precaution. If ultimate disposal was to be in an open dump, he believed that the noncombustibles should be passed through an incinerator before being hauled from the hospital.[223] Such incineration was apparently intended to eliminate contaminants associated with the noncombustibles. The Virginia State Department of Health, noting "contaminated" items from hospitals being brought to open dumps, stated that such wastes "constitute a health hazard when placed on an open dump site, not only to the men handling them but also to scavengers at the site." Even in one instance where hospital waste was brought to a municipal incinerator, it was "still felt that a hazard does exist to the truck men."[298]

An interesting problem in the ultimate disposal of hospital solid waste occurred at the compost plant serving Johnson City, Tennessee. Hospital waste was initially accepted at this facility. However, disposable hypodermic needles in the waste presented "unacceptable hazards" to the persons who manually separated the compostable material from the noncompostable, and the needles were even found in the "finished compost product."

Because of such problems, it was "necessary to refuse to accept wastes from the local hospital."[40] Solid waste regulations of the State of Minnesota require special handling of "toxic and hazardous wastes", which are defined to include pathological waste and radioactive materials, among other wastes. At sanitary landfills, such waste must be deposited in areas specifically located to avoid water pollution, and covered promptly. The landfill operator is required to maintain records of the type and quantity of hazardous waste which is received.[212]

Other Disposition of Hospital Solid Waste

There are a number of ways in which certain hospital solid wastes are utilized. Recovery of heat from incineration and use of hospital garbage as hog feed have already been discussed. Rees (1952) presented details on the salvage of various materials, with particular regard to British practice. He noted that rags, especially when made from wool, had substantial value, that the worth of scrap metal was rising, and that exposed x-ray film had value for recovery of silver nitrate and for manufacture of plastic.[250] Rourke suggested (1967) that the recycling of raw materials should be considered in the design of disposable items.[256] Other utilization of hospital wastes is practiced, including, for example, the use of afterbirth material by pharmaceutical companies and the utilization of grease in the manufacture of soap.

Various methods of disposal for hospital waste are under consideration. Repulping of disposable products has been suggested, with the pulp being collected by the supplier of the disposable products. One firm has developed a synthetic fiber which is readily dispersible in water. The possible use of this fiber for disposable items has been noted.[287] Plastics which can be disposed of more readily are being developed including one material which is soluble in cold water and one which is degraded by sunlight.[284] In research with glass, goals include the development of a material which could be dissolved in water when broken, and the formulation of a material which would fall into granules upon high impact.[1] Rayner suggested that plastic disposable items might be molded into blocks in "relatively low temperature ovens." Most infectious material would be sealed within the mass of material. Rayner also suggested the possibility that a "universal solvent" for plastics might be developed soon. He noted, however, that such a solvent would probably be both toxic and expensive.[249]

Personnel Considerations

In reviewing the literature on personnel in hospital solid waste handling, four topics were found to be prominent. These were (1) the qualifications of personnel, (2) considerations of efficiency, (3) hazards to personnel involved in solid waste handling, and (4) supervision.

Regarding qualifications, Baker observed that personnel in solid waste handling at hospitals seemed to have "very limited knowledge" of proper techniques. The only exception which he noted was for personnel handling solid waste in "hazardous areas", such as radiology, operating rooms, and pathology. Baker emphasized that proper training of personnel was an important need.[22] The American Hospital Association recommended that "all new hospital employees should be carefully oriented to the importance of infection control." The high turnover rate among hospital employees justified a formal continuing orientation program. In addition to orientation, programs of continuing education were recommended for various categories of hospital employees. It was suggested that these programs include basic concepts of infection control, job hazards, and other topics appropriate for each group of employees.[7] Michaelsen considered that the training of waste disposal personnel was important.[206] The Hospital Research and Educational Trust provides training materials for certain housekeeping employees and other hospital personnel.[143] Other references showed recognition of the need for instruction in particular topics, including separation of solid waste sent to pulping equipment,[242] operation of chutes,[95] handling of infectious waste,[223] and correct use of plastic bags as receptacle liners.[297]

A study reported by Bond, Chaffee, and Stoesser provided detailed information regarding the qualifications of supervisory personnel in engineering and maintenance departments. While noting that high levels of formal education, such as college graduation, were not encountered very frequently among such personnel, they observed a "proliferation of diplomas, certificates [and] licenses," together with considerable interest in continuing education.[34] Such continuing education could also be of value to personnel who supervise solid waste handling at hospitals.

Falick commented on the inefficiency of personnel utilization in the manual conveyance of solid waste.[93] However, a certain consultant's report on materials handling in a large medical center indicated that a "manual or semimanual system is going to be more economical" than any of certain specified automated systems.[198] One reference provided basic data for evaluating employee efficiency.[60] Other considerations of efficiency have already been discussed, including, for example, the inefficiency of manually charging incinerators.

Vincent considered that infection from solid waste was a significant hazard to hospital solid waste collection personnel.[297] Michaelsen noted that air-borne pathogens from solid waste could contaminate the clothing of waste collection personnel.[206] Goates reported on the provision of gloves and mask to the incinerator operator at a certain hospital.[113] Negus suggested that protective clothing be provided to personnel handling infectious solid waste.[223] Another reference included the recommendation (1952) that personnel who collect solid waste wear heavy gloves and be warned to take appropriate precautions when contacting waste which could cause cuts.[8] The Army Medical Service School specified protective apparel, including gloves, mask, and outer clothing. The clothing was to be laundered at least once each day. Immunization also was recommended.[19] The American Hospital Association suggest immunization of various hospital personnel, and listed diseases against which protection might be appropriate.[7] Koppenhauer recommended interlocking charging doors and other measures to protect incinerator operators.[175] Hazards from incinerating solid waste and from used disposable needles have already been discussed.

Proper supervision of personnel involved in solid waste handling was described by one reference as "strict, constant, and centralized."[251] Another reference cited poor supervision as an explanation for low quality housekeeping service, apparently including solid waste handling.[98] Adequate supervision was also cited as a necessity in one study of solid waste handling at a certain hospital.[28]

III. PROCEDURE

Preliminary Development of Methodology

Review of the literature revealed no tested methodology for a quantitative study of hospital solid wastes. Therefore, it was necessary to devote considerable time and effort to developing procedures, forms, and methods of data analysis for the research. The research was envisioned as empirical, and, from the beginning of the study the researchers used direct measurement of solid waste quantities and direct observation and interview of hospital personnel as the primary approach. Other approaches were possible. The investigators in this study might, for example, have attempted to evaluate waste quantities by gathering data on hospital purchases of supplies. However, the techniques selected were considered to be the ones most amenable to execution during the selected brief visits to hospitals and the ones which related most directly to hospital design and operation.

Orientation Study. For initial orientation, the investigators visited two nearby hospitals. One was University Hospitals, located on the University of Minnesota campus, and the other was a local general hospital of smaller size. Activity associated with these two hospitals included the following:

1. Interviews with numerous staff members at the two hospitals, including personnel in administration, engineering, housekeeping, laboratories, surgery, maternity, food service, central supply. pharmacy, and other areas of the hospitals.
2. Visits to various areas of the hospitals, accompanied by appropriate staff members, for first-hand observation of conditions relating to solid waste.
3. Observation of the collection of solid waste within the hospitals, by accompanying custodial employees on their regular collection routes.
4. Conferences with staff of the University of Minnesota who were involved with various aspects of the handling and disposal of solid waste from University Hospitals, including health physics staff, sanitarians, and members of the faculty.
5. Inspection of various facilities located away from University Hospitals, but related to its solid waste disposal, including the University of Minnesota incinerator, radioactive waste storage facilities at the University Health Service, and the Rosemount Research Center.

At this time, initial attempts were made to determine waste quantities. An investigator was stationed at a point where custodial personnel brought solid waste, and weighed, measured, and classified the material as it was delivered. The monitoring points at these two hospitals were the incinerator rooms and the loading dock areas.

Development of Tentative Methodology at Five Local Hospitals. In order to develop tentative methodology, five additional hospitals in the Minneapolis-St. Paul area were selected for study. These institutions were intended to include a wide variation in characteristics, in order that the methodology developed be applicable generally. Examples of the variation among hospitals in this sample are as follows:

Date of original construction: 1887 to 1965

Bed capacity, including newborn bassinets: 79 to 590

Community setting: Three hospitals in central city, one in a suburb, and one in a small town on the outskirts of the metropolitan area.

Surveys at the five local hospitals resulted in a number of accomplishments. Procedures were developed for obtaining data on waste quantities and on various characteristics of hospital solid waste handling systems. Tentative procedures were developed for obtaining necessary community-related data. Preliminary methods of data analysis were also devised. A very important accomplishment was the design of a set of data forms, arranged in such a way that data recorded during a visit to a hospital could be directly transferred to punch cards for computer input. The tentative methodology was now considered ready for further development in the second stage of the research.

Refinement of Methodology Using a Nationwide Sample of Purposively Selected Hospitals

The second stage of the study was intended to test the tentative procedures and forms and provide any necessary additional development of research methodology. The number of hospitals for this stage of the research was set at 25 and these were to be located throughout the nation. Selection criteria included (1) limitation to nongovernmental, nonprofit, general hospitals, (2) composition of the sample such that it possessed approximately the same geographic and size distributions as all similar hospitals (a criterion which was modified, as described later), and (3) inclusion of only hospitals with 50 or more adult beds. The lower limit of 50 adult beds was determined by consultation with several persons professionally employed in hospital-related activity. Recommendations for setting the lower limit ranged from 30 to 100 beds. The recommendation for the lowest value was based on the large number of small hospitals, and the highest value was based largely on an expectation of small hospitals becoming less common. The selected lower limit of 50 beds was considered a reasonable intermediate position, recognizing the validity of the various positions presented.

It was decided to include a smaller than proportionate number of hospitals of less than 100 beds in the second stage of the study. This was based on the expectation of lesser variability in these institutions than in larger hospitals.

Each of the 25 hospitals agreed to a survey. Each survey was scheduled for completion in two days by a research team of two.

Study at the 25 purposively selected hospitals of the second stage of the study permitted considerable improvement in methodology. Substantial additions were made to the data which were collected, and a few types of data were eliminated from consideration. Other advances during the second stage of the study included the following:

1. Written policies were prepared regarding the collection of data, coding of information on forms, analysis of data, and other matters.
2. Efficiency of performing surveys was increased, seemingly permitting hospital visits to be scheduled for one day.

Full-Scale Study

The third stage of the research, which was the full-scale stage of the study, made use of the methodology developed in the earlier stages. The variability in data from the second stage was used to estimate the number of surveys required for the full-scale stage of the study. Table 11 shows the results of the estimation based on the analysis of data for two variables. Because of the necessity of planning well in advance of the start of the full-scale stage of the study, only data from the first 14 of the 25 hospitals visited in the second stage were used. The same analysis was made for other variables. It was estimated that approximately 100 surveys would allow determination of 90 percent confidence intervals for the true means (estimated means, plus or minus 10 percent) for the most important variables considered in the research. Hospitals were selected using the listing in the then current "Guide Issue" of Hospitals, Journal of the American Hospital Association.[4] The manner of selection was as follows:

1. All nongovernmental, nonprofit, general hospitals with 50 or more adult beds were identified in the "Guide Issue" dated August 1, 1967. At the time that this was done, the number of such hospitals was very close to 2,500.

TABLE 11

ESTIMATED NUMBERS OF SURVEYS REQUIRED FOR SPECIFIED LEVELS OF PRECISION IN THE MEANS OF TWO VARIABLES

Variable	a	b	Estimated Number of Surveys
Lb/Day/Patient	0.02	0.05	672
	.02	.10	168
	.05	.10	119
	.10	.10	84
	.15	.10	64
Cu ft/Day/Patient	0.02	0.05	328
	.02	.10	82
	.05	.10	58
	.10	.10	41
	.15	.10	31

Data are for 1-a confidence interval for true mean, $\bar{x} \pm b\,\bar{x}$.

Basis: Variability in data from first 14 hospitals visited during second stage of study.

2. A table of random numbers was used to select a page number in the "Guide Issue" and a position on the page. Beginning with the hospital thus identified, every one hundreth hospital was selected for inclusion in the study.
3. The process in the preceding step was performed four times, resulting in the desired four samples of 25 hospitals each.

This procedure, which was convenient to use, would not produce a random sample. Although the sample obtained in this manner did not appear biased, certain analyses which follow are valid only to the extent that the sample can be considered to approximate a random sample. An attempt was made to exclude University Hospitals, since consultation indicated that these would be atypical. When it was decided not to attempt to evaluate seasonal effects in the manner first proposed, the four samples were later combined into one.

Performance of the Study

Personnel. Surveys at the hospitals were generally performed by two persons, one a public health engineer and one a sanitarian. In addition, nonprofessional hourly personnel were used in several surveys.

Equipment. The basic equipment used in the determination of solid waste quantities was a "HOMS" Model 300-D HH hand-carry model scale capable of taking weights up to 300 lbs with graduations to tenths of pounds.

The accuracy of the scale was verified by an inspector of the State of Minnesota, Department of Public Service, Weights and Measures Division. Table 12 indicates the calibration found for the instrument. The scale was found to meet the State of Minnesota maintenance standard for commercial scales (maximum error of 1.5 oz per 100 lbs), and a seal was affixed to the instrument attesting to its accuracy.

Forms. Precoded forms were used for the full-scale study. The scope of the survey forms included the following: (see appendix also)

1. Form HSW-1, "Background Information on Hospital": Included information on hospital construction; control; approvals; teaching activities; facilities; bed capacity; census; numbers of staff and trainees; numbers of surgical procedures, outpatient visits, and live births; and other data.
2. Form HSW-2, "On-site Solid Waste Treatment and Disposal": Included information on solid waste containment, transport, and storage at the hospital; radioactive solid waste; disposal of casts, medications, needles and syringes; and related data.

TABLE 12

CALIBRATION OF SCALE USED IN STUDY

Scale Reading	True Reading	
Pounds	Pounds	Ounces
10	9	15 7/8
30	29	15 3/4
50	49	15 3/8
100	99	15
150	149	14 1/2
200	199	14 1/8
250	249	13 3/4
300	299	12 3/4

Date of test: October 10, 1967.
Testing agency: State of Minnesota,
Department of Public Service,
Weights and Measures Division.
Scale: HOMS, model 300-D HH,
Serial No. 0921.

3. Form HSW-3, "On-site Solid Waste Treatment and Disposal-Continuation": Included information on incineration; grinding with discharge to sewerage system; handling and disposition of human tissue, animal carcasses, bacteriological cultures, and other laboratory waste; and other treatment and disposal of solid waste at the hospital.
4. Form HSW-4, "Municipality Study": Included general characteristics of the community, hauling of solid waste from the hospital, community solid waste system, conditions at the community disposal site receiving solid waste from the hospital, and other data.
5. Form HSW-5, "Quantities Survey": Included a description of the quantities survey and a portion of the survey results, comprising data developed from certain preliminary calculations.
6. Form HSW-6, "Quantities Survey-Continuation 1": Analysis of size of loads of solid waste collected by various hospital personnel, and breakdown of solid waste weight by method of treatment and disposal.
7. Form HSW-7, "Quantities Survey-Continuation 2": Breakdown of solid waste weights by source of

waste within the hospital.

8. Form HSW-8, "Quantities Survey-Continuation 3": Breakdown of solid waste weights by type of waste.
9. Form HSW-9, "Personnel Study": Functions of various hospital departments in solid waste handling; administration, personnel time expended on solid waste handling; personnel costs; requirements for employees collecting solid waste in the hospital; injuries and infections related to solid waste handling; protective clothing; and related data.

Scheduling Visits to Hospitals. The 100 hospitals were arranged into 16 groups so that the number and location of hospitals in each group would permit the entire group to be visited in one trip. The order in which each group of hospitals would be visited was then selected by using a table of random numbers. Table 13 lists the groups of hospitals in the originally proposed sequence and indicates the number of hospitals, states represented, and the estimated number of days required to visit the hospitals in each group.

The listed sequence was followed generally in performing surveys, with only minor variations made necessary by the requests of hospitals for changes in survey date. Surveys in the full-scale stage were scheduled for Mondays, Wednesdays, and Fridays in nearly every instance. The weekends and

TABLE 13

ORGANIZATION OF GROUPS OF HOSPITALS PROPOSED FOR FULL-SCALE RESEARCH

Proposed Sequence of Survey Performance	Proposed Number of Hospitals	States Represented	Estimated Days in the Field
1	4	Ohio Pennsylvania West Virginia	9
2	6	Michigan Minnesota Wisconsin	12*
3	7	Pennsylvania New York	17
4	7	Indiana Kentucky Ohio	17
5	6	Indiana Michigan Ohio	13
6	6	Illinois Michigan	13
7	6	Maryland New Jersey Pennsylvania Virginia	13
8	3	Iowa Nebraska	6
9	6	Illinois Kansas Missouri	13

TABLE 13 (continued)

Proposed Sequence of Survey Performance	Proposed Number of Hospitals	States Represented	Estimated Days in the Field
10	7	Colorado North Dakota Oregon Utah Washington	15
11	7	California	17
12	7	Alabama Florida Georgia Louisiana Mississippi	17
13	8	North Carolina South Carolina Tennessee Virginia	19
14	9	Connecticut New Jersey New York	20
15	6	Arizona Arkansas New Mexico Texas	13
16	5	Massachusetts New Hampshire Rhode Island	12
Total:	100		

*Excludes one day for a survey proposed for Minneapolis.

intervening days were used for travel.

The mechanics of scheduling visits to the hospitals in a particular group included the following steps:

1. The principal investigator sent an introductory letter to a responsible official, such as the administrator, at each hospital in the group. The letter briefly described the research.
2. After approximately 2 weeks, a researcher telephoned the responsible official at each hospital. The researcher described the study in greater detail, answered questions concerning the research, and solicited a response as to whether the hospital could participate in the research. If the answer was affirmative, then the researcher and the hospital official would agree upon a date for a visit to the hospital.
3. After surveys had been scheduled at all possible hospitals in the group, letters confirming the arrangements were sent.
4. A researcher telephoned each hospital shortly before the research visit to confirm arrangements for the quantities survey.

The disposition of the 100 hospitals selected for the full-scale study was as follows:

Research visit made to hospital:	80
Survey specifically refused by hospital administration:	11
No definite answer obtained from the hospital:	5
Survey cancelled by University:	4
Total:	100

The hospitals refusing to participate in the research cited the following reasons:

Staff too busy:	5
Not possible to have all necessary staff members present for survey:	2
Organizational changes:	1
No reason given:	3
Total:	11

Collection of Survey Data. The tabulation of data for each hospital began with assembly of published information, as follows:

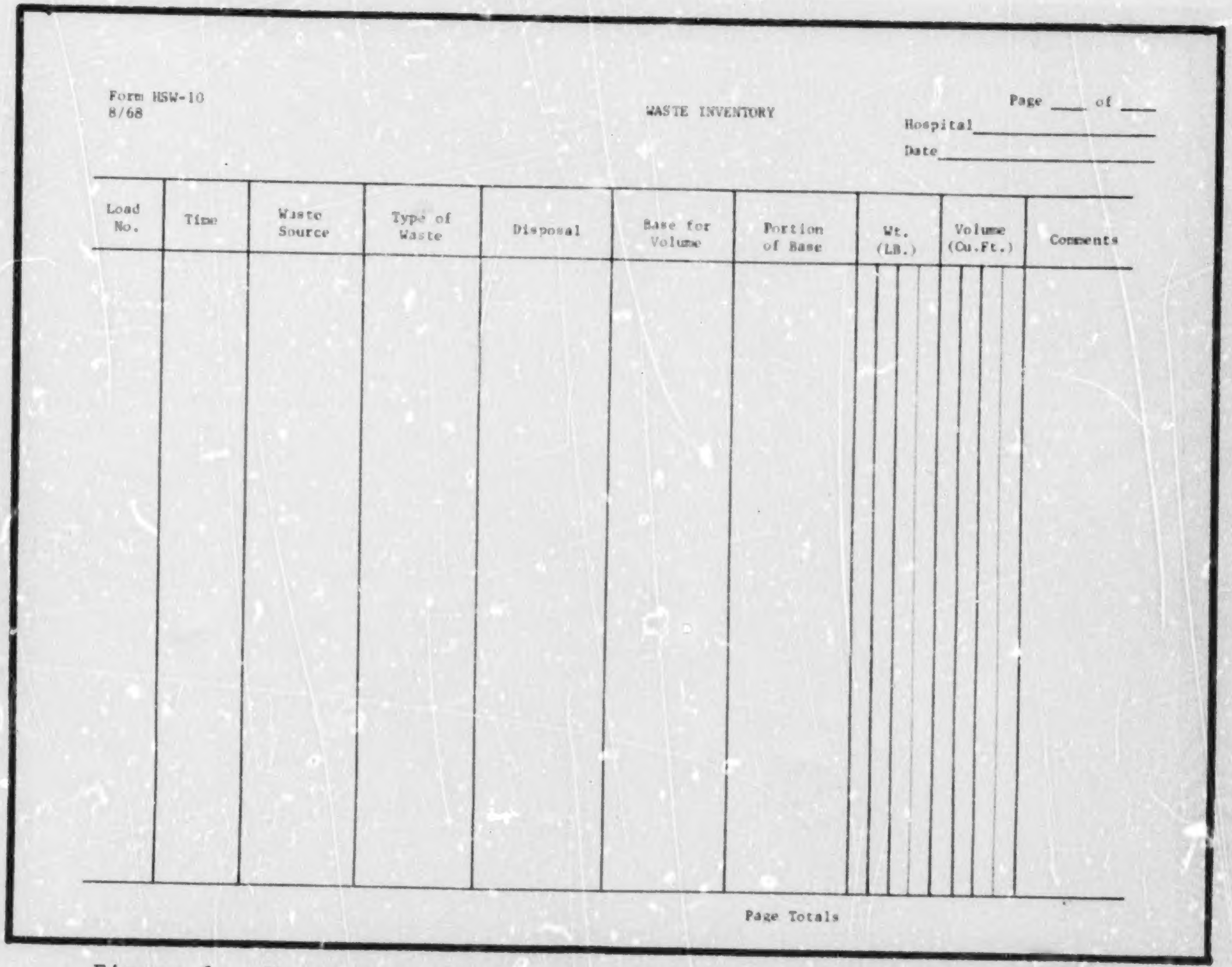
1. Data regarding various hospital characteristics, including facilities, educational programs, bed capacity, average census, accreditation status, and number of staff members were obtained from the most recent "Guide Issue" of Hospitals, Journal of the American Hospital Association.[4, 5, 6]
2. Data on community population were obtained from publications of the United States Bureau of the Census. Recent estimates of community population were obtained from The Municipal Yearbook.[164]
3. Data on solid waste handling in the community were

obtained, for those communities for which it was available, from Refuse Collection Practice.[13]

On the day scheduled for the survey, the investigators would arrive at the time that the hospital had previously indicated that internal solid waste collection began. This was as early as 5:00 a.m. in one instance, and was rarely later than 9:00 a.m. The monitoring of waste quantities was continued throughout the day, while other survey activity was in progress. Figure 1 shows the Waste Inventory Form used in the quantities surveys. A researcher would station himself at a point to which all or most waste collected in the hospital was brought, such as an incinerator room. Arrangements would be made with waste collection personnel to notify the investigator of waste brought to other points. The scale would be transported, as necessary, to measure such waste.

The basic procedure for the quantities survey was as follows:

1. Loads of waste received were numbered in sequence, and the time of delivery was recorded. A load was defined as the quantity of waste brought by one person in one trip. When accumulations of waste were monitored, no load numbers were assigned.
2. The investigator asked the person bringing the waste the source within the hospital. Observation



Form HSW-10
8/68

WASTE INVENTORY

Page ____ of ____
Hospital____________
Date____________

Load No.	Time	Waste Source	Type of Waste	Disposal	Base for Volume	Portion of Base	Wt. (LB.)	Volume (Cu.Ft.)	Comments
						Page Totals			

Figure 1. Waste inventory form used for determination of quantities of solid waste.

was used to confirm the source of waste, and one alternative response was recorded from among those listed in Table 14. This list is included on research form HSW-7, with minor variations. (see Appendix)

3. The type of waste was determined by observation and inquiry, as necessary. Types of waste considered in the research were ashes, biological material, combustible rubbish, construction and demolition waste, garbage, noncombustible rubbish, radioactive waste, sweepings, yard refuse, mixed, other, and unknown. This list is included on research form HSW-8, with minor variations. (see Appendix)
4. The method of disposal was determined by observation and inquiry, as necessary. Methods of disposal considered in the research are listed in Table 15. This list is included on research form HSW-6, with minor variations. (see Appendix)
5. Waste was weighed to the nearest one-tenth of a pound. Items or bags of waste of differing source, type, or method of disposal were weighed separately. No attempt was made to separate the contents of individual bags of solid waste. Bags of waste were

TABLE 14

LIST OF SOURCES OF HOSPITAL SOLID WASTE USED IN QUANTITIES SURVEYS

1. Administrative and other offices
2. Central supply
3. Classrooms and other teaching facilities
4. Construction and/or demolition
5. Dietary facilities
6. Emergency
7. Extended care
8. Grounds
9. Hospitality shop
10. Housekeeping
11. Intensive care
12. Isolation
13. Laboratories
14. Laundry
15. Maintenance
16. Maternity
17. Morgue
18. Nursing stations, except as noted elsewhere
19. Outpatient department
20. Pediatric care
21. Pharmacy
22. Physical therapy
23. Psychiatric care
24. Public areas
25. Rehabilitation
26. Residences
27. Storerooms
28. Surgery
29. X-ray
30. Mixed
31. Other
32. Unknown

TABLE 15

LIST OF METHODS OF HOSPITAL SOLID WASTE DISPOSAL USED IN QUANTITIES SURVEYS

---

1. Disposal at the hospital
    - A. Incineration
    - B. Grinding, and discharge to sewerage system
    - C. Mixed, other, and unknown disposal at the hospital (e.g., waste weighed, and unknown fractions then incinerated and buried at the hospital)

2. Disposal after hauling away
    - A. Incineration
    - B. Sanitary landfill
    - C. Dumping
    - D. Hog feeding
    - E. Mixed, other, and unknown disposal after hauling away (e.g., waste weighed and hauled away, with unknown fractions then disposed of by incineration and open dumping)

3. Mixed disposal at the hospital and disposal after hauling away (e.g., waste weighed, and unknown fractions then incinerated at the hospital and hauled away)

4. Other than the above

5. Unknown

classified according to a particular waste source, type, or method of disposal only if at least an estimated 90 percent of the weight pertained thereto.

6. A steel measuring tape was used for determining the volume corresponding to each weight. Volumes pertained to the solid waste as transported in the hospital's internal collection system. The standard was to record measurements to the nearest one-fourth of an inch. An attempt was made to assure reliability of the volume estimates by comparing determinations made independently by the two members of the survey team.

Interviews at the hospital usually began with the administrator or another high-level hospital executive. After this, interviews were usually conducted in the areas of the hospital where individual staff members were employed, thus permitting the investigators to make necessary observations concurrent with the discussions. Table 16 lists the persons interviewed and the length of time required typically for each. In many instances, and particularly at larger hospitals, it was necessary to interview additional persons. When a department director or other person proposed for interview was unavailable,

TABLE 16

LIST OF PERSONS INTERVIEWED AT HOSPITALS

	Person Interviewed	Typical Time Required (Minutes)
1.	Administrator	45
2.	Engineer	45
3.	Food service supervisor	30
4.	Executive housekeeper	30
5.	Obstetrical service nurse	15
6.	Pathologist	15
7.	Laboratory chief	15
8.	Radiologist	15
9.	Pharmacist	15
10.	Chief operating room nurse	15
11.	Personnel officer	15
12.	Director of nursing	15
13.	Other persons, as necessary	15 (Each)

it was nearly always possible to obtain the needed data from an assistant.

It was not practical usually to make advance arrangements for obtaining data regarding community aspects of the research. Inquiry on the day of the survey generally revealed where the necessary data could be obtained. It was possible usually to make an appointment with a responsible person, such as a director of public works, superintendent of a sanitation division, or a supervising sanitarian, despite the short notice. The usual sequence was to interview a knowledgeable person about overall community solid waste collection and disposal, and then to visit the disposal site which received the general waste that was being hauled from the hospital.

Processing of Data

Processing of data began before the investigators left a hospital. At that time, data were reviewed for completeness in order to permit deficiencies to be eliminated before leaving the community. Frequently, preliminary calculations were also begun while still at the hospital, although it was usually necessary to complete such work later. Preliminary calculations included determining volumes from field measurements, adding weights found in the quantities surveys, calculating waste contributions per patient per day and per admission, calculating waste densities, calculating percents of waste brought in peak hours, calculating average loads, calculating waste breakdowns according to source within the hospital, type of waste, and method of disposal, and calculating other values. At most hospitals, it was not practical to measure directly wastes sent to grinders and discharged to the sewerage system. Biological material deposited in grinders invariably was reported by hospital staff members to constitute only a very small quantity. Such material was not considered further in evaluating solid waste quantities. For food waste grinders, estimates of the quantity of waste discharged through the units were derived by analyzing data on weights of garbage found in a few instances where it was possible to weigh the garbage being sent to such units. Two cases were distinguished: (1) grinders used for both dishwashing and food preparation, and (2) grinders used for dishwashing only. Garbage disposed of through food waste grinders was estimated to be approximately 2.5 lbs per day per patient for those cases in which grinders were used for both food preparation and dishwashing, and as 1.7 lbs per day per patient where grinders were used for dishwashing only. These values should be considered as approximations, and no statements are made regarding the statistical significance of the estimates. Volumes of waste discharged to grinders were based on the preceding estimates and the density of water. Estimates of the volume of garbage sent to grinders were 0.04 cubic ft per day per patient, for those cases in which grinders were used for food preparation and dishwashing, and 0.03 cubic ft per day per patient, where used for dishwashing only. The estimates were used, as appropriate, to place data from all hospitals on the same basis.

After completing the preliminary calculations, data for each survey were reviewed for accuracy. Data were then keypunched and a preliminary compilation was prepared by a digital computer. Data in this compilation were checked for uniformity and consistency of methodology. Considerable editing of the data was done at this point. Additional data analysis of various types was then performed.

IV. SURVEY ADMINISTRATIVE DATA, COMMUNITY CHARACTERISTICS, AND DESCRIPTION OF HOSPITALS VISITED

Survey Administrative Data

Variables of Time. Tables 17 through 20 show the distribution of hospitals visited with respect to year, month, season, and day of the week of survey visit. Data refer to the quantities surveys, and more specifically, to the day on which the greater part of the monitored solid waste was generated. Data are included for the orientation stage of the research, although the information from these surveys is incomplete (seven hospitals), and in many cases cannot be compared with data from the subsequent stages.

The distribution of surveys according to year, shown in Table 17, records the progress of the study, and gives an indication of the length of time required to complete each stage of the investigation. The first survey began Sept. 8, 1966, and the last survey was on Nov. 21, 1969. More than one-half of the surveys were performed during 1969.

Table 18, which indicated the distribution of surveys according to month, shows that the months during which most surveys were performed were August, September, October, and November. Certain factors which were not fully subject to

TABLE 17

DISTRIBUTION OF SURVEYS ACCORDING TO YEAR

Stage of Research		Number of Surveys Performed During Indicated Year			
	1966	1967	1968	1969	Total
Orientation	2	5	-	-	7
Second Stage	-	17	8	-	25
Full-Scale	-	-	19	61	80
Total:	2	22	27	61	112

TABLE 18

DISTRIBUTION OF SURVEYS ACCORDING TO MONTH

	Number of Surveys Performed During Indicated Stage of Research			
Month	Orientation	Second Stage	Full-Scale	Total
January	-	-	7	7
February	-	-	5	5
March	-	2	7	9
April	2	-	6	8
May	2	-	7	9
June	1	6	-	7
July	-	3	5	8
August	-	7	7	14
September	1	4	6	11
October	-	-	16	16
November	1	-	9	10
December	-	3	5	8
Total:	7	25	80	112

TABLE 19

DISTRIBUTION OF SURVEYS ACCORDING TO SEASON

Stage of Research	Number of Surveys Performed During Indicated Season				
	Summer	Fall	Winter	Spring	Total
Orientation	1	1	-	5	7
Second Stage	18	3	1	3	25
Full-Scale	15	33	16	16	80
Total:	34	37	17	24	112

TABLE 20

DISTRIBUTION OF QUANTITIES SURVEYS ACCORDING TO DAY OF WEEK

	Number of Surveys Performed During Indicated Stage of Research			
Day of Week	Orientation	Second Stage	Full-Scale	Total
Monday	-	2	26	28
Tuesday	1	10	4	15
Wednesday	4	-	26	30
Thursday	-	3	2	5
Friday	-	10	21	31
Other	2*	-	1†	3
Total:	7	25	80	112

*One instance of a survey being performed in two parts, on Tuesday and Thursday, and one instance of a survey being performed in three parts, on Monday, Wednesday, and Friday.

†Sunday.

choice influenced the month during which surveys were performed. Surveys during the second stage of the research were performed during periods when much of the University was in recess, including summer months, Christmas recess, and Easter recess. The start of the full-scale research was not until October 1968 largely because of the time required to revise survey procedures and forms. Similar factors apply to the distribution of surveys according to season, shown in Table 19.

Table 20 summarizes data regarding the day of the week on which quantities surveys were performed. In the second stage of the study, two days were considered necessary for each survey, and two surveys were scheduled each week. One day for travel was generally required between the surveys. At each hospital, the quantities determination was made during the second day of the survey. Thus, most of the determinations of solid waste quantity were performed on Tuesdays and Fridays in the second stage of the study. A similar explanation applies to the full-scale stage of the research. Surveys were limited to one day each, with intervening days used for travel. Hence, determinations of solid waste quantity, as well as gathering of other field data, were made on Mondays, Wednesdays, and Fridays. The few exceptions to performing surveys on days indicated here occurred when (1) accumulations of solid waste generated on the preceding day were monitored, or (2) favorable conditions made it practical to perform surveys sooner than scheduled.

Hospital Locations. Table 21 shows the distribution of hospitals visited during the study by state and census region. During the orientation phase of the research, only hospitals in the Minneapolis-St. Paul metropolitan area were studied. In the second stage, all census regions were represented, including 19 different states. In the full-scale study, all census regions were again represented, and a total of 35 different states were visited. As already described, 20 of the hospitals identified for inclusion in the full-scale stage of the study were not visited. The location of these hospitals is shown in Table 22. The hospitals which were not visited were located in all census regions, and included institutions in 16 states. Of these, four states were not otherwise represented in the full-scale study.

Table 23 compares the location of hospitals visited in the research, by census region, with the distribution of all nongovernmental, nonprofit hospitals.[5] The geographic distributions of hospitals in both the second stage and full-scale studies resemble those for all nongovernmental, nonprofit hospitals. The differences between the geographic distributions of the hospitals included in the study, and that of all nongovernmental, nonprofit hospitals are largely due to hospitals included in the study being restricted (1) to general hospitals, and especially, (2) to those with 50 or more adult beds.

TABLE 21

DISTRIBUTION OF SURVEYS ACCORDING TO STATE AND CENSUS REGION

Census Region	States	Number of Surveys		
		Orientation Stage	Second Stage	Full-Scale Stage
1	Connecticut	-	-	2
	Maine	-	-	-
	Massachusetts	-	2	1
	New Hampshire	-	-	1
	Rhode Island	-	-	1
	Vermont	-	-	-
	Total:		2	5
2	New Jersey	-	2	3
	New York	-	1	7
	Pennsylvania	-	1	6
	Total:		4	16
3	Delaware	-	-	-
	District of Columbia	-	-	-
	Florida	-	-	1
	Georgia	-	-	1
	Maryland	-	1	1
	North Carolina	-	1	3
	South Carolina	-	-	2
	Virginia	-	1	3
	West Virginia	-	-	2
	Total:		3	13
4	Illinois	-	-	5
	Indiana	-	-	2
	Michigan	-	-	5
	Ohio	-	1	5
	Wisconsin	-	3	2
	Total:		4	19
5	Alabama	-	-	1
	Kentucky	-	2	3
	Mississippi	-	-	-
	Tennessee	-	-	1
	Total:		2	5

TABLE 21 (continued)

Census Region	States	Number of Surveys		
		Orientation Stage	Second Stage	Full-Scale Stage
6	Iowa	-	1	1
	Kansas	-	1	-
	Minnesota	7	1	1
	Missouri	-	-	3
	Nebraska	-	-	1
	North Dakota	-	1	1
	South Dakota	-	-	-
	Total:	7	4	7
7	Arkansas	-	-	1
	Louisiana	-	-	-
	Oklahoma	-	-	-
	Texas	-	1	1
	Total:		1	2
8	Arizona	-	1	1
	Colorado	-	1	1
	Idaho	-	-	-
	Montana	-	-	-
	Nevada	-	-	-
	New Mexico	-	1	-
	Utah	-	-	1
	Wyoming	-	-	-
	Total:		3	3
9	Alaska*	-	-	-
	California	-	2	7
	Hawaii*	-	-	-
	Oregon	-	-	1
	Washington	-	-	2
	Total:		2	10
	Grand Total:	7	25	80

*Not included in study.

TABLE 22

GEOGRAPHIC DISTRIBUTION OF HOSPITALS IDENTIFIED FOR INCLUSION IN FULL-SCALE STUDY, BUT NOT VISITED

Census Region	State	Number of Hospitals
1	Massachusetts	2
2	New York	1
	Pennsylvania	1
3	Florida	2
	Maryland	1
4	Illinois	2
	Ohio	1
	Wisconsin	1
5	Mississippi	1
6	Iowa	1
	Kansas	1
	Minnesota	1
7	Louisiana	1
	Texas	2
8	New Mexico	1
9	Oregon	1
	Total:	20

TABLE 23

COMPARISON OF GEOGRAPHIC DISTRIBUTION OF HOSPITALS VISITED IN STUDY WITH DISTRIBUTION OF NONGOVERNMENTAL, NONPROFIT HOSPITALS

	% of Hospitals Visited			% of All
Census Region	Orientation Stage	Second Stage	Full-Scale Stage	Nongovernmental, Nonprofit Hospitals*
1		8	6	8
2		16	20	16
3		12	16	12
4		16	24	20
5		8	6	5
6	100	16	9	14
7		4	3	8
8		12	4	6
9†		8	13	10
Total:	100%	100%	101%	99%

*Adapted from 1968 "Guide Issue" of *Hospitals*, *Journal of the American Association*.[5]

†Excludes data for Alaska and Hawaii, which were not included in the research.

However, approximate figures developed during the research indicated that the geographic distribution of the 80 hospitals in the full-scale stage of the study was close to that of all hospitals of the same type, and closer than the distribution of hospitals visited in the second stage.

Community Characteristics

It was believed important in the research to consider the hospital in the context of the surrounding community. Table 24 shows the range of populations for the municipalities visited, based on the 1960 census. Generally, the population listed is for the municipality within which the hospital was located. In a few instances where a hospital was located in an unincorporated area adjacent to a municipality, the population listed was that for the municipality. The smallest community visited had a population of 389, and the largest almost 8,000,000. In approximately 75 percent of the cases, the community population had increased from 1950 to 1960.

Included among the community characteristics considered was presence in a standard metropolitan statistical area. This was defined for census purposes as, essentially, an area including at least one city with 50,000 inhabitants or more, or, under certain conditions, two cities with this population combined, together with contiguous metropolitan counties having economic

TABLE 24

POPULATION DISTRIBUTION OF MUNICIPALITIES VISITED

Range of Population	Number of Municipalities Orientation Stage	 Second Stage	 Full-Scale Stage
0 - 9,999	1	1	18
10,000 - 19,999	-	7	12
20,000 - 29,999	1	2	10
30,000 - 39,999	-	3	8
40,000 - 49,999	-	-	5
50,000 - 99,999	-	1	4
100,000 - 199,999	-	2	3
200,000 - 299,999	-	2	3
300,000 - 399,999	1	1	3
400,000 - 499,999	4	1	1
500,000 - 999,999	-	3	8
1,000,000 and greater	-	1	3
No data	-	1	2
Total:	7	25	80

and social relation to the city.[291] Data regarding presence in a standard metropolitan statistical area (SMSA) were as follows:

	Number of Hospitals Visited		
	Orientation Stage	Second Stage	Full-Scale Stage
In SMSA	7	16	48
Not in SMSA	0	9	32

Hospital Characteristics

Table 25 indicates the year in which the original construction was completed at the hospitals visited in the study. Data for the orientation stage are excluded here and in other discussion of hospital characteristics since complete information was not obtained for these institutions. At those institutions where the original facilities were completely replaced, the date of contruction of the replacement was used. In those instances in which an existing structure was converted into a hospital, the date on which the alteration into a hospital was completed was used.

It is apparent that many of the institutions visited were old, with over 40 percent of the hospitals included in Table 25 originally constructed more than 50 years ago. Counterbalancing this was the continuing expansion and major alteration of the institutions, as summarized in Table 26. Expansion or major alteration was underway during the visit at 28 percent of the

TABLE 25

YEAR OF ORIGINAL CONSTRUCTION OF HOSPITALS VISITED

Range of Years	Number of Hospitals	
	Second Stage	Full-Scale Stage
Before 1900	6	14
1900 - 1909	4	6
1910 - 1919	1	14
1920 - 1929	7	10
1930 - 1939	-	5
1940 - 1949	-	6
1950 - 1959	5	8
1960 - present	2	17
Total:	25	80

TABLE 26

YEAR OF COMPLETION OF LAST EXPANSION OR OTHER MAJOR ALTERATION OF HOSPITALS VISITED

Range of Years	Number of Hospitals	
	Second Stage	Full-Scale Stage
Before 1950	-	2
1950 - 1954	2	5
1955 - 1959	5	6
1960 - 1964	4	9
1965 - present	7	20
Under construction during visit	6	23
No expansion or major alteration	1	15
Total:	25	80

hospitals, and had been completed at an additional 26 percent of the hospitals since 1965. No relation was noted between date of original construction and date of last expansion or major alteration. To be considered as an expansion or major alteration, the basic criterion was that construction or alteration involved or increased bed capacity or floor area by at least 10 percent.

The research plan was to consider only nongovernmental, nonprofit, general hospitals. Several notations should be made regarding possible exceptions to this. In one instance, the hospital was owned by the municipality, but was operated by an independent, nongovernmental hospital association. Another possible exception was an institution owned by a hospital district. The district was empowered to issue bonds with the same advantage in interest as tax-exempt municipal bonds.

Most of the hospitals had been accredited by the Joint Commission on Accreditation of Hospitals, as shown in the following summary:

	Number of Hospitals	
	Second Stage	Full-Scale Stage
Accredited	23	75
Not Accredited	2	5

These data reflect the high degree of accreditation found in nongovernmental, nonprofit hospitals, which was last reported (1969) as 96 percent for institutions with 50 adult beds or more.[6] Most of the hospitals visited also possessed current state licenses.

All hospitals visited were classified as general with respect to service, in accordance with the scope of the research. However, a wide variation existed in hospital facilities, services, and teaching activities. Table 27 lists the frequency with which certain selected facilities and services were present at the hospitals, and indicates comparison with frequencies for similar hospitals (nongovernmental, nonprofit hospitals with 50 or more adult beds), in those instances where available. It is apparent that hospitals visited in the full-scale stage were much the same as the comparison hospitals with respect to the noted facilities and services. Hospitals in the second stage of the study more frequently included the specified facilities than the comparison hospitals. These data probably reflect bias in selecting hospitals for the second stage.

Nearly all hospitals had central kitchens for food preparation. An infrequent pattern was for food to be purchased already divided into individual portions and to be heated in microwave ovens at nursing stations. Although this constitutes a radical departure from usual hospital food service practice it was being utilized by two of the hospitals and several other administrators expressed interest in such a system. Nearly all hospitals visited also had some food service equipment at nursing stations, commonly used only for minor nourishments. It was

TABLE 27

PERCENT OF HOSPITALS HAVING SPECIFIED FACILITIES AND SERVICES

Facility or Service	% of Hospitals Second Stage	% of Hospitals Full-Scale Stage	% for Similar Hospitals
Pathology laboratory	88	86	85*
Radioisotope use	72	54	48*
Cobalt therapy	20	16	17*
Radium therapy	68	46	51*
Research	24	17	-
Laundry	60	94	-
Obstetrical service	96	89	-
Psychiatric inpatient unit	16	15	19†

Comparison data are for nongovernmental, nonprofit hospitals with 50 or more adult beds.[5]

*From American Hospital Association.[4]

†From American Hospital Association.[5]

frequently a moot question as to whether such an installation constituted a floor kitchen. Generally, a facility was considered to be a floor kitchen only if it was used for large-scale food preparation, portioning of food prepared elsewhere, or dishwashing.

Hospitals varied widely in the educational programs which were available, as summarized in Table 28. Hospitals visited in the full-scale stage had nearly the same frequency of selected educational programs as all nongovernmental, nonprofit hospitals with 50 or more adult beds. Hospitals surveyed during the second stage showed higher frequencies of certain educational programs. The nursing schools listed were for training professional nurses in most instances. Technician training usually referred to personnel for radiology or laboratory departments. Clinical experience usually referred to a nursing program in which the hospital was associated with a college or other educational institution.

The hospitals which were visited showed a wide range in adult bed capacity, as indicated in Table 29. Considering both the second stage and full-scale phases of the research, the range in adult bed capacity was 52 to 1,226. The mean was 237 adult beds for the second stage, and 222 adult beds for the full-scale stage of the study. The corresponding median numbers of adult beds were 234 and 147. Table 29 shows the effect of purposely

TABLE 28

EDUCATIONAL PROGRAMS AT HOSPITALS

Educational Program	% of Hospitals Second Stage	% of Hospitals Full-Scale Stage	% for Similar Hospitals
Residency (Medical)	48	27	28
Internship (Medical)	44	24	23
Medical school affiliation	32	10	11
Hospital controlled professional or practical nursing school	32	25	25*
Technicians	48	45	-
Clinical experience	72	70	-

Comparison data are for nongovernmental, nonprofit hospitals with 50 or more adult beds.[5]

*Comparison value considered only professional nursing schools.

TABLE 29

DISTRIBUTION OF ADULT BED CAPACITY

Range of Number of Adult Beds	% of Hospitals Second Stage	% of Hospitals Full-Scale Stage	% for Similar Hospitals
50 - 99	16	27	32
100 - 199	28	31	32
200 - 299	24	14	17
300 - 399	20	11	10
400 - 499	8	9	5
500 and more	4	7	5
Total:	100%	99%	101%

Comparison data are for nongovernmental, nonprofit hospitals with 50 or more adult beds.[5]

biasing selection of the 25 hospitals in the second stage to larger institutions. In the full-scale study, it can be seen that the size distribution of hospitals was much like that for similar hospitals.

Since the term bed capacity is ambiguous, in this study it was considered to include operating beds set up, staffed, and available for use by inpatients at the time of the survey. Generally, beds in facilities such as labor rooms, postoperative recovery rooms, and other special purpose areas were not included, conforming to the definition listed by the American Hospital Association.[6]

The number of newborn bassinets should also be considered in discussing hospital capacity. Considering both the second stage and full-scale studies, the range was zero to 90 bassinets. The mean was 33 for the second stage hospitals (median 27), and 27 for the full-scale study (median 19).

Table 30 lists data on average daily inpatient census, including newborn. For the 25 hospitals visited during the second stage of the study, the range was 46 to 425, and the mean was 205 (median 196). For the 80 hospitals in the full-scale study, the range was 28 to 1,100, and the mean was 189 (median 127). The difference in the distribution of average total census between the two samples resulted from the purposeful bias toward larger institutions in the selection of hospitals for the second

TABLE 30

AVERAGE DAILY INPATIENT CENSUS, INCLUDING NEWBORN

Range of Average Total Patient Census	% of Hospitals	
	Second Stage	Full-Scale Stage
Less than 99	20	45
100 - 199	32	21
200 - 299	28	11
300 - 399	16	13
400 - 499	4	5
500 and more	0	5
Total:	100%	100%

TABLE 31

PERCENT OCCUPANCY AT HOSPITALS VISITED

Range of % Occupancy	% of Hospitals	
	Second Stage	Full-Scale Stage
40 - 49	4	3
50 - 59	12	11
60 - 69	12	25
70 - 79	36	39
80 - 89	32	21
90 - 99	4	1
Total:	100%	100%

stage.

Hospitals generally do not operate at capacity, as indicated by the variable percent occupancy, which is patient census compared with bed capacity. Percent occupancies at the hospitals surveyed are summarized in Table 31. The two distributions are similar, and it is apparent that almost all of the hospitals visited were operating well-below capacity.

Patient census alone is not an adequate measure of the utilization of a hospital. Three variables which describe hospital utilization in terms of patient care are summarized in the following, and show wide variation:

	Second Stage			Full-Scale Stage		
Variable	Range	Mean	Median	Range	Mean	Median
Outpatient visits per year	0 to 50,000	10,000	4,000	0 to 400,000	23,000	10,000
Surgical procedures per year	400 to 9,700	4,800	4,200	0 to 26,000	4,000	2,300
Live births per year	100 to 3,500	1,200	700	0 to 4,300	970	550

For comparison, averages calculated from data for nongovernmental, nonprofit hospitals having 50 or more adult beds were (1) 18,200 outpatient visits per year, and (2) 880 live births per year.[5]

Tables 32 and 33 list data regarding numbers of staff members and persons in training at the hospital. Employees

TABLE 32

NUMBER OF HOSPITAL EMPLOYEES

Range of Number of Employees	% of Hospitals	
	Second Stage	Full-Scale Stage
Fewer than 100	4	6
100 - 199	12	27
200 - 299	16	17
300 - 399	12	9
400 - 499	16	7
500 - 599	36	21
1,000 - 1,499	4	7
1,500 - 1,999	-	3
2,000 and more	-	1
Total:	100%	98%

TABLE 33

NUMBER OF PERSONS IN EDUCATIONAL PROGRAMS

Range of Number of Persons in Educational Programs	% of Hospitals	
	Second Stage	Full-Scale Stage
None	36	34
Fewer than 50	32	31
50 - 99	12	9
100 - 149	12	11
150 - 199	4	9
200 - 249	-	4
250 - 299	-	1
300 and more	4	1
Total:	100%	100%

were not considered to include practicing physicians, private duty nurses, or volunteers. Full-time equivalents are included for part-time personnel.[6] Considering both the second stage and full-scale phases of the study, the number of employees ranged from 70 to 2,966, with a mean of approximately 480 (median 320). Similarly, the number of persons in training at the hospitals ranged from zero to 324, with a mean of 56 (median 22). The median staff per bed ratio was between 1.50 and 1.75, and the median staff plus trainees per bed ratio was between 1.75 and 2.00.

Data on staff and trainee housing at the hospitals visited are summarized in the following:

	Staff Housed		Trainee Housed	
	Range	Mean	Range	Mean
Second Stage	0 to 11	2.1	0 to 125	29
Full-Scale Stage	0 to 270	13	0 to 224	23

Considering that the above data vary considerably, the observed means would not be highly reliable as estimators of the true means. Data include members of families of staff members and persons in educational programs. In a few instances, other persons residing at hospitals, such as retired members of religious orders residing at church affiliated hospitals, are included also in the figures.

V. SOLID WASTE HANDLING AND DISPOSAL SYSTEMS

Storage and Collection of Solid Waste

Enclosure of Solid Waste in Bags. Plastic bags were used most commonly by hospitals to enclose solid waste. Data indicated that 68 percent of the 25 hospitals surveyed in the second stage and 79 percent of the 80 hospitals in the full-scale stage of the research used plastic bags for most of their solid waste. Paper bags were used as the primary means of enclosure in only a few of the hospitals. It was far more common to find paper bags, especially waterproof ones, being used to enclose relatively small amounts of wet or contaminated material.

The bulk of the solid waste was found unbagged at 12 percent of the hospitals in the second stage of the study, and at 16 percent of the hospitals in the full-scale research. This usually meant that the solid waste was stored in direct contact with receptacles and that transfer of the waste to other receptacles was necessary. However, deficiencies also were found at hospitals where bags generally were used to enclose the solid waste. Numerous examples were seen of the bags occasionally not being used, of bags not being closed, of disposable bags being used again, of bags breaking or leaking, of bags being used only in waste collection, and of other inadequacies. Few of the hospitals were using disposable bags satisfactorily to enclose solid waste at the points of generation.

Collection of Solid Waste Within the Hospital. Most of the hospitals used manually propelled carts of some variety for the collection of solid waste. The most frequently used carts had rigid walls made from wood, metal, or other materials. Such carts were used at 40 percent of the hospitals in the full-scale stage of the research, which are the only hospitals for which satisfactory data were obtained. Flat carts, either carrying waste in receptacles or without receptacles, were used as the primary means of solid waste conveyance in 26 percent of the hospitals. Flat carts were used for a small amount of the waste in many additional hospitals. Carrying solid waste by hand was the primary means of solid waste conveyance at only 8 percent of the hospitals, but carrying by hand was used to at least a small extent at nearly every hospital.

The following summarizes the number of chutes used for solid waste:

Number of Chutes	Number of Hospitals Second Stage	 Full-Scale Stage
None	20	51
1	3	17
2	2	7
3	-	1
4	-	4
Total:	25	80

Chutes were an important means for conveying solid wastes at only 32 percent of the institutions, and were found more frequently and in larger numbers at hospitals with larger bed capacities. Several instances were encountered in which linen chutes were reserved for conveying solid waste during specified times of the day.

Other methods of transporting solid waste within the hospital were encountered. Pulping and transport of waste as a slurry was found at two institutions, and a pneumatic chute system was found to be used at one hospital. Several hospitals utilized self-propelled vehicles towing carts filled with solid waste.

Central Storage of Solid Waste. Consideration of solid waste storage was limited to central storage, which was defined to include storage before the waste was incinerated or hauled from the hospital for disposal. The following summarizes the number of locations found for the central storage of solid waste:

Number of Storage Locations	Number of Hospitals	
	Second Stage	Full-Scale Stage
1	13	37
2	8	32
3	3	8
4 or more	1	3
Total:	25	80

Types of storage areas also included refrigerated garbage storage in the dietary department, storage of noncombustibles in the vicinity of incinerators, and storage at nurses' residences and extended care facilities.

There was considerable variation in the central storage capacity available for solid waste at the hospitals, as indicated by the data in Table 34. The range in storage capacity, 10 cu ft to 1,540 cu ft, was due partly to the wide differences in hospital practice regarding the types of waste which were hauled away. At many hospitals, the types included only noncombustible rubbish and incinerator residue, while at some institutions nearly all solid waste was hauled away for disposal. Data on capacity of central storage were obtained only in the full-scale stage.

Detailed data were gathered regarding storage for the hauler who removed the greatest weight of general solid waste, termed the major hauler. Storage of solid waste for the major hauler was outdoors and without shelter at 56 percent of the hospitals visited in the full-scale stage of the study. Specialized shelters, outbuildings, and solid waste storage rooms were the most common among other practices encountered.

The types of containers used for storage for the major hauler included the following, again considering only data for the full-scale stage of the research:

TABLE 34

CENTRAL STORAGE CAPACITY FOR HOSPITAL SOLID WASTE

Range of Central Storage Capacity cu ft	Number of Hospitals Full-Scale Stage
Less than 50	11
50 - 99	15
100 - 149	12
150 - 199	9
200 - 499	20
500 - 999	6
1,000 and greater	7
Total:	80

Type of Container	Number of Hospitals
No containers	5
Metal cans and similar receptacles	25
Improvised containers	17
Noncompacting bulk receptacles	37
Stationary compactor receiver receptacles	9
Other	7

Many hospitals used several types of receptacles.

Incineration at the Hospital

By far the majority of hospitals used incineration. Data on the number of incinerators used are as follows:

	Number of Hospitals	
Incinerators	Second Stage	Full-Scale Stage
None	1	10
1	21	52
2	3	14
3 and more	-	4
Total:	25	80

Multiple incinerators were encountered primarily at hospitals with larger bed capacities.

Data regarding the rated capacity of incinerators were frequently not available, although desirable. The following summarizes available data on the capacity of the hospital incinerators:

	Rated Capacity of Incinerators Pounds Per Hour Range	Mean	Number of Hospitals
Second Stage	100 to 1,350	440	11
Full-Scale Stage	100 to 800	350	43

If multiple incinerators were used at a single hospital, then the rated capacity recorded was that for the unit receiving the greatest weight of solid waste. This unit was termed the major incinerator. Rated capacity was much less frequently available for other units, and it was also observed that the second, third or fourth incinerators at a hospital typically were used only occasionally.

Types of solid waste sent to the major incinerator are characterized below:

Type of Solid Waste	Number of Hospitals Incinerating Indicated Type of Waste Second Stage	Full-Scale Stage
Combustible rubbish	22	68
Garbage	4	15
Biological material	20	59
Noncombustible rubbish	5	20
Other	3	7

Noncombustible rubbish and garbage usually were present only in small proportion. In most cases this resulted from poor separation of types of waste.

Flue-fed incinerators were encountered as the major incinerator at only five of the hospitals visited in the second and full-scale stages of the study. Such incinerators were used to burn small amounts of solid waste at many additional hospitals.

The incinerators usually were not operated by persons skilled and knowledgeable in proper procedures. At only 39 percent of the hospitals using incinerators was operation limited to a specifically designated operator or group of operators. At other hospitals using incinerators, the typical practice was for the various persons collecting solid waste to also load it into the incinerator.

Location of the incinerator varied considerably. An outdoor location was used at 18 percent of the hospitals, frequently without shelter of any kind. Personnel were exposed to adverse weather in the course of conveying waste to outdoor units and performing necessary operation. A separate room was the most frequent location for incinerators, being found at 48 percent of the institutions. Incinerator rooms occasionally were found to be uncomfortable and even hazardous for personnel operating incinerators, with problems including high temperature, smoke and dust in the air, and danger from exploding aerosol containers. Incinerators also were located in boiler rooms and in various other places.

Grinding of Solid Waste for Discharge to Sewerage System

Grinders were frequently used at the hospitals to discharge a portion of the solid waste to the sewerage system. The following summarizes the type of waste sent to grinders:

	% of Hospitals	
Type of Waste	Second Stage	Full-Scale Stage
Garbage	80	84
Biological material	16	27

Food waste grinders were located in a number of places as follows:

	% of Hospitals	
Location	Second Stage	Full-Scale Stage
Food preparation in central kitchen	52	51
Dishwashing in central facility	76	83
Potwashing in central facility	28	20
Nursing station floor kitchen	-	1

The number of food waste grinders ranged from zero to 19 at the hospitals. However, the median at hospitals having such units was two. The hospitals using grinders to dispose of biological material typically had one or two such units, although one institution which was visited had four grinders for this purpose.

In all instances except one, grinders at the hospitals discharged to a public sewer system, with the waste in most instances going to a sewage treatment plant. At one hospital, the grinders discharged to a small extended aeration sewage treatment plant serving only the institution. Since this plant was overloaded by organic material, use of the grinders was restricted severely.

Hazardous Solid Waste

Biological Materials. Table 35 lists disposal methods found for selected varieties of biological material. Note that complete data were obtained for only the full-scale stage of the research. The table lists data only for the method of disposal used for the greatest weight of each type of material at each hospital. Generally, hospitals also used other methods of disposal for portions of each type of material. For example, hospitals invariably respected the convictions of those among their patients who wished human tissue to be buried, although this was the major method of disposition at relatively few of the hospitals.

It is interesting that biological material was hauled away with mixed solid waste in a number of instances. Often, the biological material consisted of specimens which had been preserved in a formalin solution for a considerable time, or

TABLE 35

DISPOSITION OF SELECTED VARIETIES OF BIOLOGICAL MATERIAL

Type of Biological Material	% of Hospitals (Full-Scale Stage)					
	Incineration On-site	Burial	Hauling Away with other waste	Use by Drug Firm	Other	Not Applicable*
Afterbirth	26	-	7	51	3	13
Amputated tissue	50	9	11	-	6	24
Autopsy tissue	31	34†	4	-	4	27
Animal carcasses	15	-	1	-	1	83
Bacteriological cultures	69	-	21	-	6	4

*No material of indicated type discarded.

†Refers to tissue replaced in body.

bacteriological cultures which had been autoclaved.

Radioactive Solid Waste. Since more than half of the hospitals visited used radioisotopes for medical purposes, the handling and disposal of radioactive solid waste was considered particularly important. Disposal of radioisotope waste included storage until decay had satisfactorily reduced activity at 76 percent of the hospitals having such waste. The decayed material was generally disposed of with other solid waste, using routine procedures. Contaminated waste was incinerated at the hospital, without storage to reduce activity, at 17 percent of the hospitals using radioisotopes. At one hospital, radioactive waste was hauled away, without benefit of decay, mixed with other solid waste. The amounts of radioactive material involved appeared to be small in the instances of disposal without prior decay.

Chemical Waste. Chemical waste was generally intimately mixed with other solid waste or present as a contaminant. A common example was an organic solvent absorbed in paper toweling from a hospital laboratory.

In the course of surveys, several incidents were observed in which large quantities of chemical solid waste caused problems at the hospitals. At one institution, approximately three cu ft of hypochlorite bleaching powder were dumped into a bulk solid waste receptacle, resulting in considerable discomfort to hospital personnel in the vicinity. In another incident, a quart of what appeared to be a strong acid was placed into the receptacle, with little apparent concern for employees.

Disposable Needles and Syringes. Disposable needles and syringes were found to constitute a significant safety hazard to personnel who handled hospital solid waste, with 69 percent of the hospitals in the full-scale stage reporting this as a problem.

The hospitals generally had established policies providing for the safe disposal of needles and syringes. In the typical case, the policy would require replacing the sheath on the needle, bending the needle or breaking it by hand, and sealing the needle in a disposable container. It was found that the policies frequently were disregarded at most hospitals, with disposable needles often being found mixed with other solid waste, and even protruding from bags of waste. Several custodians were observed as they were accidentally pricked by disposable needles.

The possibility of hazard away from the hospital should be considered in the disposal of needles and syringes, since these were hauled away without incineration at 45 percent of the hospitals.

Hauling and Disposal of Solid Waste from the Hospital

Hauling of Solid Waste from the Hospital. In many instances, several haulers were found to remove solid waste from the hospital, as indicated:

Number of Haulers	Number of Hospitals	
	Second Stage	Full-Scale Stage
1	14	52
2	10	24
3	1	4
Total:	25	80

These data do not include certain specialized hauling, such as separate hauling of radioactive solid waste or biological material.

Table 36 shows the important role of private haulers in removing solid waste from the hospitals. Municipal agencies and even the hospitals themselves also hauled away waste in many instances. Contract arrangements between municipalities and private haulers were found at only a few hospitals. Other haulers of solid waste included hog farmers.

There was a wide variation in the frequency with which waste was hauled from the hospitals, as shown in the following summary of the number of collections of solid waste per week (major hauler):

	Collections Per Week		
	Range	Mean	Median
Second Stage	1 to 18	6.2	6
Full-Scale Stage	1 to 21	4.5	4

TABLE 36

TYPES OF HAULERS SERVING HOSPITALS

Type of Hauler	Number of Hospitals Second Stage	 Full-Scale Stage
Private	16	45
Municipal	7	30
Contract	1	3
Hospital itself	3	17
Other	2	13

The type of waste removed by the major hauler is summarized below:

Type of Waste Hauled	% of Hospitals: Second Stage	% of Hospitals: Full-Scale Stage
Noncombustible rubbish	100	100
Combustible rubbish	72	64
Garbage	60	53
Other	16	31

Disposal of Solid Waste Hauled from the Hospital. Disposal of the greatest weight of the solid waste removed from the hospitals was usually at a municipal site, as can be seen from the following summary:

Control of Disposal Site	% of Hospitals: Second Stage	% of Hospitals: Full-Scale Stage
Municipal	68	73
Contract	12	5
Private	12	23
Other	4	-
No data	4	-
Total	100	101

Data pertain to the type of disposal provided for the greatest amount of solid waste hauled from each hospital. Land disposal sites, mostly open dumps, were found to receive the greatest part of the solid waste from almost 90 percent of the hospitals, and municipal incinerators were used for most of the waste hauled from the other hospitals.

Selected Administrative and Personnel Factors Relating to Solid Waste Handling

It was frequently the case that a large number of hospital departments had responsibilities for solid waste handling. The data which follow, derived from the full-scale stage of the study, show the frequency with which various departments were found to have responsibility for hospital solid wastes:

Hospital Department	% of Hospitals
Housekeeping	91
Maintenance or engineering	93
Food service	75
Nursing:	
Operating room	27
Other nursing	16
Other	70

Although the housekeeping department usually had primary responsibility for solid waste collection within the hospital, numerous other hospital departments had regular responsibility for facets of the waste collection. The engineering or maintenance department most commonly had primary responsibility for the disposal of solid waste.

The number of persons involved in solid waste handling at the hospitals was frequently large, as indicated in the following summary (full-scale stage):

Hospital Department	Number of Personnel Range	Mean
Housekeeping	0 to 28	4.7
Maintenance or engineering	0 to 5	1.2
Food service	0 to 12	2.3
Nursing:		
Operating room	0 to 4	0.4
Other units	0 to 13	1.4
Total:		10.0

These data do not include administrative personnel.

The following summarizes education and experience requirements for solid waste collection personnel at hospitals in the full-scale stage of the research:

Education or Experience Required	% of Hospitals Education	Experience
None	37	85
No specific number of years, but certain knowledge or skills required	46	11
Specific number of years	16	4
Total:	99	100

Where knowledge or skill is listed as a requirement for personnel, the reference is usually to a minimal ability to read, write, and speak English.

VI. ANALYSIS OF DATA

Quantity of Solid Waste Per Day

The 80 hospitals in the full-scale stage of the research generated a mean weight of 1,910 lbs per day of solid wastes, and a mean volume of 430 cu ft per day. Corresponding values found in the second stage of the research were similar, with the means being 1,950 lbs per day and 400 cu ft per day. The ranges in total waste quantity per day were as follows:

Stage of Research	Range	
	Lbs per Day	Cu Ft per Day
Second Stage	302 to 5,027	37 to 1,026
Full-Scale	168 to 17,701	47 to 4,278

The ranges are very wide, with the smallest and largest values for total weight per day found in the full-scale study differing by a factor of more than 100. This gives an indication of the difference in the magnitude of solid waste handling requirements at hospitals.

To make these data more useful, linear regressions were performed relating total weight and total volume to hospital bed capacity and patient census. The regressions generally yielded quite high correlation coefficients, approximately 0.9 or greater. The equations found were as follows, based on data developed in the full-scale stage of the study:

(1) $y_1 = 11\ x_1 - 760$

(2) $y_2 = 2.5\ x_1 - 200$

y_1 = pounds per day of solid waste.

y_2 = cubic feet per day of solid waste.

x_1 = bed capacity, including newborn bassinets.

The regression lines, data points, and 95 percent confidence intervals for the regressions are shown in Figures 2 and 3. These correlations are not applicable to small hospitals.

Contributions of Solid Waste Per Patient Per Day

The contributions of solid waste of hospitals in the full-scale stage of the study had means of 8.72 lbs per day per patient and 1.97 cu ft per day per patient. The 95 percent confidence intervals for the true means were 8.18 to 9.26 lbs per day per patient, and 1.80 to 2.14 cu ft per day per patient. The means for the 25 hospitals in the second stage of the research were 9.02 lbs per day per patient, and 1.86 cu ft per day per patient. The corresponding confidence intervals were wider for these means, possibly reflecting the lesser degree of development of technique in this earlier phase of the study and the smaller sample size.

The ranges in the values for contribution of solid waste per patient were wide, as can be seen from the following:

Figure 2.
Linear Regression of Total Quantity of Solid Waste Per Day, By Weight, Versus Bed Capacity

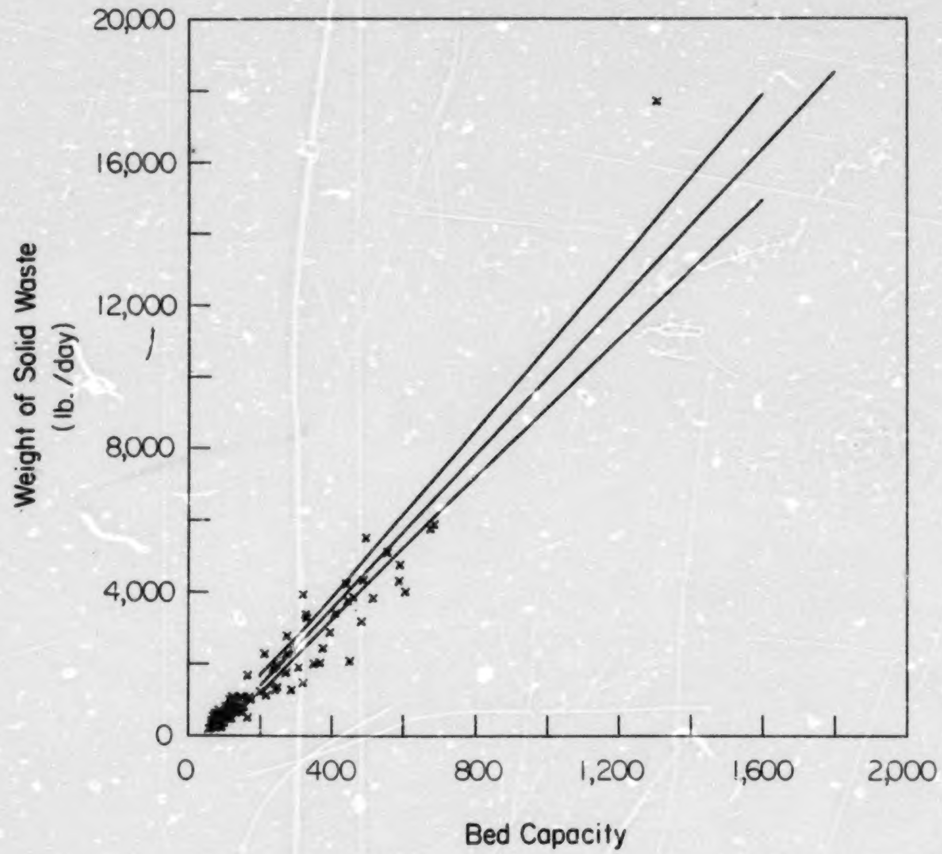
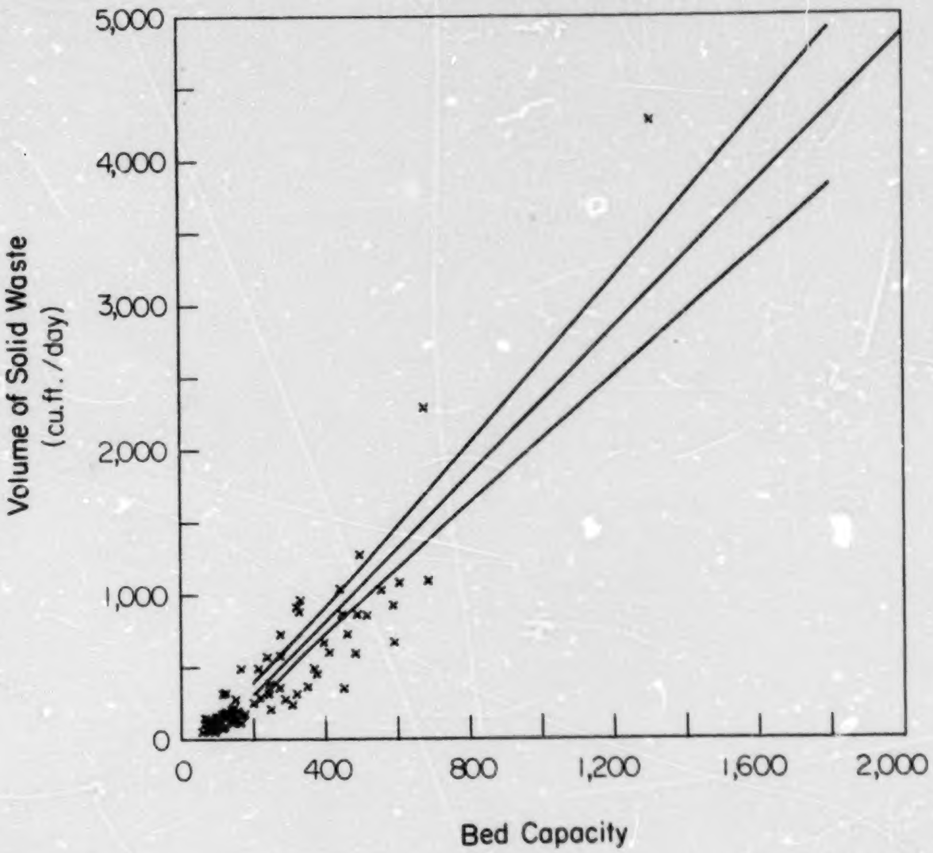


Figure 3.

Linear Regression of Total Quantity of Solid Waste Per Day, By Volume, Versus Bed Capacity



	Range	
	Lbs Per Day Per Patient	Cu Ft Per Day Per Patient
Second Stage	5.1 to 13.7	0.8 to 3.3
Full-Scale Stage	4.7 to 16.2	1.0 to 4.0

Frequency counts for contributions of solid waste per patient are listed in Tables 37 and 38 for weight and volume basis respectively.

Comparison of Contribution of Waste and Administrative Factors.

Comparison with Year of Visit to Hospital. Comparison of mean contribution of solid waste by weight for the three years during which hospitals were visited yielded the following results:

Year	Mean Lbs Per Day Per Patient
1967	8.9
1968	7.9
1969	9.1

No trend was apparent in these means. The noted difference is probably largely the result of the hospitals visited during 1968 having a smaller mean bed capacity than the hospitals visited during the other two years.

Comparison with Month of Visit to Hospital. Similar calculations were made for the month when the various hospitals were visited. The pattern was for the winter months, including December, January, and February, to be below the mean, and

TABLE 37

FREQUENCY COUNTS FOR RANGES OF WEIGHT OF SOLID WASTE GENERATED PER DAY PER PATIENT

Range of Lbs Per Day Per Patient	Hospitals Visited: Second Stage Number	Second Stage %	Full-Scale Stage Number	Full-Scale Stage %
4.0 - 4.9	-	-	2	3
5.0 - 5.9	2	8	3	4
6.0 - 6.9	3	12	17	21
7.0 - 7.9	3	12	16	20
8.0 - 8.9	5	20	12	15
9.0 - 9.9	5	20	7	9
10.0 - 10.9	2	8	9	11
11.0 - 11.9	2	8	4	5
12.0 - 12.9	2	8	4	5
13.0 - 13.9	1	4	4	5
14.0 - 14.9	-	-	1	1
15.0 - 15.9	-	-	-	-
16.0 - 16.9	-	-	1	1
Total:	25	100%	80	100%

TABLE 38

FREQUENCY COUNTS FOR RANGES OF VOLUME OF SOLID WASTE GENERATED PER DAY PER PATIENT

Range of Cu Ft Per Day Per Patient	Hospitals Visited			
	Second Stage		Full-Scale Stage	
	Number	%	Number	%
0.5 - 0.9	2	8	-	-
1.0 - 1.4	2	8	21	26
1.5 - 1.9	11	44	28	35
2.0 - 2.4	7	28	14	17
2.5 - 2.9	2	8	8	10
3.0 - 3.4	1	4	3	4
3.5 - 3.9	-	-	5	6
4.0 - 4.4	-	-	1	1
Total:	25	100%	80	99%

spring and summer months, such as May, June, and July to be above the mean. The differences are not necessarily seasonal effects, since, as has already been described, the hospitals visited during each month did not constitute a randomly selected sample.

Comparison with Day of Visit to Hospital. Comparison of contributions of solid waste per patient with day of the week showed the following results:

		Lbs Per Day Per Patient	
Day	Number of Observations	Mean	Range
Sunday	1	7.6	--
Monday	28	8.6	5.0 to 14.2
Tuesday	14	8.1	5.1 to 12.7
Wednesday	26	8.9	4.7 to 16.2
Thursday	5	8.4	6.8 to 10.5
Friday	31	9.3	4.8 to 13.4
Total:	105		

None of the means varied from that for other values enough to be considered different at the 95 percent confidence level.

Comparison with Census Region. An attempt was made to find geographical patterns in the contribution of solid waste. Initially, mean contributions were calculated for each of the 11 states in which a minimum of three hospitals were visited. These results were interesting. For example, the seven hospitals located in California showed the highest mean contribution, with 10.9 lbs per patient per day (range 8.0 to 13.2). Nevertheless, it was judged that comparison of mean contributions with census region would yield more reliable results, being based on larger samples. Data in this regard are summarized in Table 39. Means which were significantly higher than others at the 95 percent confidence level included those for region one, the New England states, and region nine, the three Pacific coast states. The only mean significantly lower than others was that for region four, which includes certain midwestern states. These results should be considered to definitely establish a difference among the regions.

Comparison of Contribution of Waste and Community Characteristics.

Comparison with Presence in a Standard Metropolitan Statistical Area. A relation appeared to exist between the quantity of solid waste per patient per day and whether the hospital was located in a standard metropolitan statistical area. This can be seen in the following:

	Located in SMSA Lb/Day/Patient			Not Located in SMSA Lb/Day/Patient		
	N	Mean	Range	N	Mean	Range
Second Stage	16	9.78	6.8 - 13.7	9	7.67	5.1 - 10.5
Full-Scale Stage	48	9.53	5.0 - 16.2	32	7.50	4.7 - 14.2

The differences were significant for each stage of the research, with probabilities of encountering such results, if there were no difference, being 0.03 and less than 0.0005, respectively,

TABLE 39

CONTRIBUTION OF SOLID WASTE PER PATIENT, BY WEIGHT, COMPARED WITH CENSUS REGION

Census Region	Number of Hospitals	Lbs Per Day Per Patient Mean	Range
1 - New England	7	10.6	6.1 - 14.2
2 - Middle Atlantic	20	9.2	5.0 - 13.6
3 - South Atlantic	16	8.2	4.7 - 10.9
4 - East North Central	23	7.4	4.8 - 11.4
5 - East South Central	7	8.7	6.5 - 12.0
6 - West North Central	11	8.6	5.1 - 16.2
7 - West South Central	3	10.2	8.0 - 12.7
8 - Mountain	6	8.5	6.8 - 10.4
9 - Pacific	12	10.4	7.6 - 13.7
Total:	105		

for the second and full-scale stages of the study.

Comparison with Population of Community. The population of the community where the hospital was located was also considered. Table 40, which indicates contribution of hospital solid waste as pounds per day per patient for various community populations, exhibits a general increase in waste contribution as population increases.

Comparison with Hospital Characteristics.

Comparison with Bed Capacity. Analysis of the data indicated evidence of a relation with bed capacity, as can be seen in Table 41. In order to consider this factor further, linear regressions were performed. Relating pounds per day per patient to bed capacity, a correlation coefficient of 0.45 was obtained. Excluding bassinets from bed capacity showed little change, and relating the logarithms of both variables actually decreased the correlation coefficient. In the regression of cubic feet per day per patient versus bed capacity, a correlation coefficient of 0.32 was obtained. Attempts to improve the correlation by excluding bassinets from bed capacity, and by correlating the logarithms of the values, were unsuccessful, as with the contributions by weight. Testing the indicated correlation coefficients for significance showed that both represented real correlations, with P less than 0.0005 and 0.001,

TABLE 40

CONTRIBUTION OF SOLID WASTE, BY WEIGHT, COMPARED WITH COMMUNITY POPULATION

Range of Community Population	Number of Observations	Mean Lbs Per Day Per Patient
Less than 10,000	19	6.9
10,000 - 19,999	19	8.1
20,000 - 29,999	12	8.7
30,000 - 39,999	11	8.6
40,000 - 49,999	5	8.8
50,000 - 99,999	5	9.7
100,000 - 199,999	5	8.9
200,000 - 299,999	5	10.5
300,000 - 399,999	4	8.9
400,000 - 499,999	2	10.1
500,000 - 999,999	11	10.6
1,000,000 and greater	4	11.3
No Data	3	
Total:	105	

TABLE 41

CONTRIBUTION OF SOLID WASTE, BY WEIGHT, COMPARED WITH BED CAPACITY

Range of Hospital Bed Capacity	Hospitals Visited					
	Second Stage			Full-Scale Stage		
	N	Mean	Est.S.D.*	N	Mean	Est.S.D.*
50 - 99	3	7.4	2.1	18	7.4	1.8
100 - 199	6	8.5	2.2	27	8.2	2.0
200 - 299	5	10.9	2.1	10	9.6	2.6
300 - 399	8	8.9	2.2	9	9.7	3.2
400 - 499	-	-	-	8	10.0	2.1
500 - 599	3	8.9	2.1	4	9.1	1.5
600 - 699	-	-	-	3	9.5	1.0
700 and more	-	-	-	1	16.2	-
Total:	25			80		

*"Est.S.D."means Estimated Standard Deviation.

respectively, for the weight and volume correlations. However, the correlations are of low degree. Figures 4 and 5 show graphs of contributions of solid waste, by weight and volume, versus bed capacity, with the 95 percent confidence intervals and the original data also shown. The equations for the two curves are as follows:

$$(3) \quad y_3 = 7.4 + 0.0053\, x_1$$

$$(4) \quad y_4 = 1.7 + 0.0012\, x_1$$

y_3 = pounds of solid waste per day per patient.

y_4 = cubic feet of solid waste per day per patient.

x_1 = bed capacity, including newborn bassinets.

Comparison with Operating Room Data. Comparison with data on operating rooms showed small indication of correlation. This can be seen from a comparison of mean pounds of solid waste per day per patient with number of operating rooms and number of surgical procedures per year as shown in Tables 42 and 43.

Comparison with Outpatient Data. Comparisons were made to evaluate the effect of outpatient activity on contribution of waste per patient. The following summarizes mean pounds per day per patient for the presence or absence of outpatient departments at the hospitals:

Figure 4.
Linear Regression of Contribution of Solid Waste Per Day Per Patient, By Weight, Versus Bed Capacity

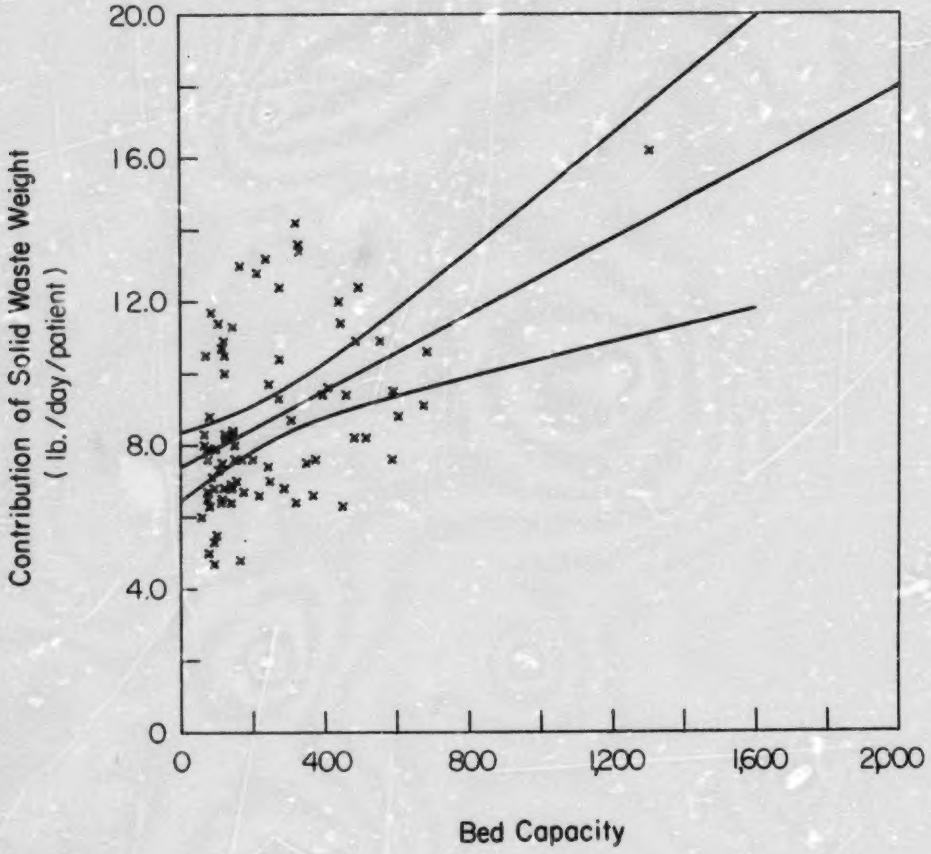


Figure 5.

Linear Regression of Contribution of Solid Waste Per Day Per Patient, By Volume, Versus Bed Capacity

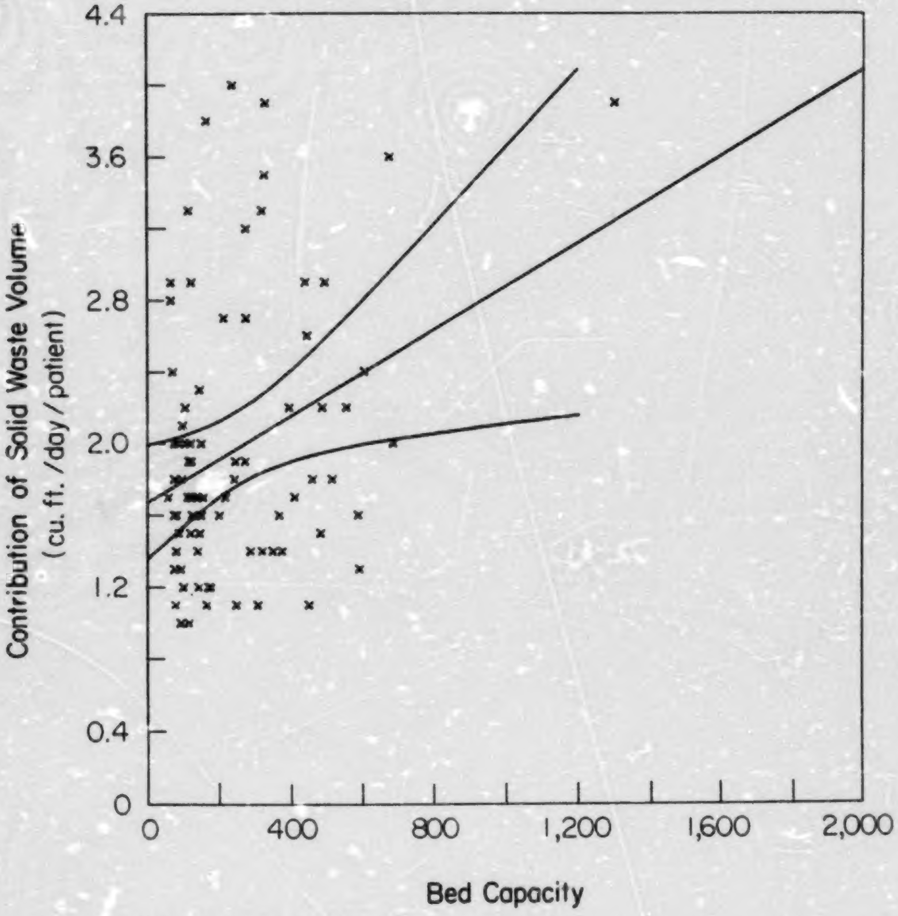


TABLE 42

CONTRIBUTION OF SOLID WASTE, BY WEIGHT, COMPARED WITH NUMBER OF OPERATING ROOMS

Range of Number of Operating Rooms	Second Stage Mean			Full-Scale Stage Mean		
	N	Lb/Day/ Patient	Est. S.D.	N	Lb/Day/ Patient	Est. S.D.
0 to 2	4	8.6	1.4	20	7.0	1.5
3 to 4	8	8.8	2.7	31	8.6	2.1
5 to 6	3	9.9	1.1	7	10.9	1.8
7 to 8	6	8.3	2.1	9	9.8	2.9
9 to 10	2	8.7	1.0	9	9.0	1.0
11 and more	2	12.0	0.8	4	11.3	3.2
Total:	25			80		

TABLE 43

CONTRIBUTION OF SOLID WASTE, BY WEIGHT, COMPARED WITH NUMBER OF SURGICAL PROCEDURES PER YEAR

Range of Number of Surgical Procedures Per Year	Second Stage Mean			Full-Scale Stage Mean		
	N	Lb/Day/ Patient	Est. S.D.	N	Lb/Day/ Patient	Est. S.D.
0 to 2,499	7	7.7	2.1	43	7.8	2.0
2,500 to 4,999	7	9.5	2.7	11	9.3	2.3
5,000 to 7,499	5	8.8	1.9	13	9.8	2.7
7,500 to 9,999	6	10.1	1.7	8	9.5	1.9
10,000 to 12,499	-	-	-	3	10.2	1.2
12,500 to 14,999	-	-	-	1	9.1	-
15,000 and more	-	-	-	1	16.2	-
Total:	25			80		

	Second Stage Mean			Full-Scale Stage Mean		
	N	Lb/Day/ Patient	Est.S.D.	N	Lb/Day/ Patient	Est.S.D.
Outpatient Department	15	9.1	2.1	73	8.8	2.4
No Outpatient Department	10	8.8	2.3	7	7.9	2.6
Total:	25			80		

The difference was not significant for either stage of the study. However, an apparent relation was found by comparing mean solid waste contribution with number of outpatient visits per year. Table 44 shows this relation, using data from the full-scale stage of the study.

Comparison with Obstetrical Service Data. In a similar manner, comparisons were made for the obstetrical service. The following summarizes mean pounds per day per patient for the presence and absence of an obstetrical service at the hospitals visited:

	Second Stage Mean			Full-Scale Stage Mean		
	N	Lb/Day/ Patient	Est.S.D.	N	Lb/Day/ Patient	Est.S.D.
Obstetrical Service	24	9.1	2.1	71	8.8	2.5
No Obstetrical Service	1	6.1	-	9	8.2	1.9
Total:	25			80		

The data yielded no indication of a significant difference in

TABLE 44

CONTRIBUTION OF SOLID WASTE, BY WEIGHT, COMPARED WITH NUMBER OF OUTPATIENT VISITS PER YEAR

Range of Number of Outpatient Visits Per Year	Number of Observations	Mean Lbs Per Day Per Patient	Estimated Standard Deviation
0 - 9,999	39	7.9	2.2
10,000 - 19,999	20	8.9	1.9
20,000 - 29,999	7	8.0	1.6
30,000 - 39,999	2	8.7	2.7
40,000 - 49,999	3	8.8	0.8
50,000 - 59,999	2	10.6	4.2
60,000 - 69,999	2	11.7	1.1
70,000 - 79,999	1	12.0	-
80,000 - 89,999	-	-	-
90,000 - 99,999	2	12.5	2.3
100,000 and more	2	14.7	2.1
Total:	80		

contribution of solid waste related to whether an obstetrical service existed at the hospital. However, comparison of mean contribution of solid waste with the number of live births per year gave indication of a correlation:

Range of Number of Live Births Per Year	Second Stage Mean			Full-Scale Stage Mean		
	N	Lb/Day/ Patient	Est.S.D.	N	Lb/Day/ Patient	Est.S.D.
0 - 499	4	8.2	2.3	31	7.6	2.0
500 - 999	9	8.6	2.5	21	8.7	2.2
1,000 - 1,499	4	9.8	2.7	9	9.7	2.4
1,500 - 1,999	4	10.3	2.1	7	9.6	2.8
2,000 - 2,499	2	8.1	0.7	5	11.1	3.3
2,500 - 2,999	1	8.1	-	3	9.1	1.6
3,000 - 3,499	-	-	-	-	-	-
3,500 - 3,999	1	9.9	-	2	10.9	2.1
4,000 - 4,499	-	-	-	2	10.3	1.6
Total:	25			80		

Comparison with Hospital Facilities and Services. An attempt was made to relate the presence of certain specialized care units with contribution of solid waste weight per patient per day. This analysis included psychiatric inpatient, rehabilitation inpatient, and extended care units. Examination of data from the full-scale stage of the research indicated that hospitals with none of these facilities had a mean solid waste contribution of 8.6 lbs per day per patient (estimated standard deviation of 2.2), while hospitals with psychiatric inpatient units had a mean of 10.4 lbs per day per patient (estimated standard deviation of 2.7). This difference was significant at

95 percent confidence level. Hospitals with extended care units were found to have a mean contribution of 7.7 lbs per day per patient (estimated standard deviation of 2.2), but this was not significantly different from hospitals with none of the specialized facilities.

Analysis also considered certain other hospital facilities and services. Data for the full-scale stage of the study are summarized in Table 45. Data indicate that the presence of a pathology laboratory, radioisotope utilization, cobalt therapy, radium therapy, or laboratory research are all related to higher contributions of solid waste per patient. The difference in solid waste contribution associated with the presence of these facilities and services was highly significant in all instances. Table 46 lists means for selected combinations of hospital facilities and services, again using data developed in the full-scale stage of the study. Although the addition of specific facilities is associated with increases in contribution of waste per patient in nearly every instance, the incremental differences are not significant.

Comparisons were made for the presence, absence, and selected combinations of educational programs at the hospitals. First, data were analyzed for the effect of a hospital controlled nursing school. The following results were obtained in this analysis, using data from the full-scale stage of the study:

TABLE 45

CONTRIBUTION OF SOLID WASTE PER PATIENT, BY WEIGHT, COMPARED WITH PRESENCE OF SELECTED HOSPITAL FACILITIES AND SERVICES

Presence of Facility or Service	Number of Observations	Mean Lbs Per Day Per Patient	Estimated Standard Deviation	P*
Pathology Laboratory:				
Present	69	9.0	2.4	-
Not Present	11	6.9	1.7	0.01
Radioisotope Utilization:				
Present	43	9.6	2.5	-
Not Present	37	7.7	1.9	0.001
Cobalt Therapy:				
Present	13	10.7	2.7	-
Not Present	67	8.3	2.2	0.001
Radium Therapy:				
Present	37	9.4	2.6	-
Not Present	43	8.1	2.1	0.02
Laboratory Research:				
Present	14	11.2	2.4	-
Not Present	66	8.2	2.1	<0.001

*P is the probability of observing results as variant as noted in the absence of a true difference.

TABLE 46

CONTRIBUTION OF SOLID WASTE PER PATIENT, BY WEIGHT, COMPARED WITH PRESENCE OF SELECTED COMBINATIONS OF HOSPITAL FACILITIES AND SERVICES

Hospital Facilities and Services	Number of Observations	Mean Lbs Per Day Per Patient	Estimated Standard Deviation
Clinical laboratory, or clinical laboratory and pharmacy	11	6.9	1.7
Clinical laboratory, pharmacy, plus pathology laboratory	19	8.1	1.7
Clinical laboratory, pharmacy, pathology laboratory, plus radioisotope utilization	13	9.2	2.2
Clinical laboratory, pharmacy, pathology laboratory, radioisotope utilization, plus cobalt therapy and radium therapy	13	10.7	2.7

	Number of Observations	Mean Lbs Per Day Per Patient	Estimated Standard Deviations
Nursing School	20	10.0	2.7
No Nursing School	60	8.3	2.1

The data from the full-scale stage of the study indicated that the presence of a hospital controlled school of nursing was highly associated with a higher solid waste contribution (P = 0.01).

Mean contributions of solid waste, by weight, are listed in Table 47 for several combinations of educational programs found at hospitals visited during the full-scale stage of the study. The mean contributions of solid waste were not significantly different, at the 95 percent confidence level, for indicated successive additions of educational programs.

Comparison with Patient Census on Day of Visit to Hospital. In order to obtain an estimate of the average number of patients in the hospital on the day of the visit, an arithmetic average was used, calculated from the census at midnight before the survey day and the census at midnight after the survey day.

Correlating the contributions of solid waste per patient per day with census on the day of the survey gave results similar to those obtained with bed capacity. Linear regression yielded

TABLE 47

CONTRIBUTIONS OF SOLID WASTE PER PATIENT, BY WEIGHT, FOR SELECTED COMBINATIONS OF HOSPITAL EDUCATIONAL PROGRAMS

Hospital Educational Programs	Number of Hospitals	Mean Lbs Per Day Per Patient	Estimated Standard Deviation
None of programs considered	17	7.5	1.8
Clinical experience only	23	8.3	2.0
Clinical experience plus any other educational program except nursing school	19	9.1	2.3
Clinical experience plus nursing school plus training of technicians, alone or with any other educational programs	14	10.4	2.9

the following equations, using data from the full-scale stage of the study:

(5) $y_3 = 7.6 + 0.0059\ x_2$

(6) $y_4 = 1.7 + 0.0014\ x_2$

y_3 = pounds of solid waste per day per patient.

y_4 = cubic feet of solid waste per day per patient.

x_2 = patient census, including newborn, on day of survey.

These equations are similar to those developed from regression with bed capacity, and the correlation coefficients are also very similar, being 0.43 and 0.32. These values indicate that the correlations are real, although of low degree. Therefore, additional factors should be related to contribution of solid waste per patient.

Several attempts were made to improve the correlations. Performing regressions with the logarithms of the data decreased the correlation coefficients to 0.41 and 0.24, for the contributions of solid waste by weight and volume respectively. By excluding newborn from the census, the correlation coefficients were reduced slightly to 0.42 and 0.31. Regressions were also performed using powers of the independent variable up to four. The equation derived for degree three was as follows:

(7) $y_3 = 6.5 + 0.022x_2 - 0.000049x^2_2 + 0.000000033x^3_2$

y_3 = pounds of solid waste per day per patient.

x_2 = patient census, including newborn, on day of survey.

This equation is interesting in that it indicates an essentially constant solid waste contribution, approximately 9.5 to 9.7 lbs per day per patient, for a range in census of approximately 250 to 700.

Comparison with Numbers of Employees and Persons Engaged in Educational Programs. Hospital employees invariably outnumbered patients at the hospitals visited. Table 48 indicates mean contributions of solid waste, by weight, for ranges of the ratio of number of employees per bed, considering the full-scale stage of the study. It is apparent that the mean contribution of solid waste per patient generally increases with increasing value of this ratio.

A similar comparison was made using the ratio of employees plus trainees per bed. The mean contributions of solid waste per patient, by weight, are listed in Table 49, again using data from the full-scale stage. A general increase in solid waste contribution is apparent as the ratio increases.

The data were analyzed to evaluate the effect of the presence of housing for employees and trainees at the hospital. The following summarizes mean contributions of solid waste, as pounds per day per patient, for the presence and absence of such

TABLE 48

CONTRIBUTIONS OF SOLID WASTE, BY WEIGHT, FOR RANGES OF RATIO OF NUMBER OF EMPLOYEES PER BED

Range of Ratio of Employees Per Bed	Number of Hospitals	Mean Lbs Per Day Per Patient	Estimated Standard Deviation
0.75 - 0.99	2	5.1	0.5
1.00 - 1.24	8	7.1	1.4
1.25 - 1.49	10	8.5	2.2
1.50 - 1.74	24	8.3	1.7
1.75 - 1.99	12	7.5	1.6
2.00 - 2.24	8	9.2	2.5
2.25 - 2.49	11	11.2	2.6
2.50 - 2.74	3	10.3	2.6
2.75 - 2.99	2	13.3	1.3
Total:	80		

TABLE 49

CONTRIBUTIONS OF SOLID WASTE, BY WEIGHT, FOR RANGES OF RATIO OF EMPLOYEES PLUS TRAINEES PER BED

Range of Ratio of Employees Plus Trainees Per Bed	Number of Hospitals	Mean Lbs Per Day Per Patient	Estimated Standard Deviation
0.75 - 0.99	2	5.1	0.5
1.00 - 1.24	7	7.1	1.5
1.25 - 1.49	7	7.6	2.0
1.50 - 1.74	19	8.6	1.8
1.75 - 1.99	12	7.8	1.7
2.00 - 2.24	12	9.3	2.1
2.25 - 2.49	5	8.4	1.9
2.50 - 2.74	7	10.8	3.4
2.75 - 2.99	5	11.2	2.9
3.00 - 3.24	1	7.6	-
3.25 - 3.49	3	11.5	3.2
Total:	80		

housing at the hospitals visited during the full-scale stage:

	With Housing Mean			Without Housing Mean		
	N	Lb/Day/ Patient	Est.S.D.	N	Lb/Day/ Patient	Est.S.D.
Staff	37	9.3	2.3	43	8.2	2.4
Trainee	24	9.8	2.7	56	8.3	2.1

It is clear that the presence of housing for either staff or trainees was associated with significantly higher contributions of solid waste (P values were 0.05 and 0.01, respectively). To further study the effect of housing of trainees, mean solid waste contributions, by weight, were calculated for ranges of number of trainees residing at the hospital. The results are listed in Table 50. A progressive increase in quantity of solid waste per patient is associated with increasing numbers of trainees residing at the hospital. A similar analysis of mean quantities of solid waste per patient was not performed for ranges of number of employees housed, since the number housed was generally small at the hospitals visited.

Comparison with Accreditation and Possession of State Licenses. Hospitals which were both licensed by the government of the state in which located and approved by the Joint Commission on Accreditation of Hospitals had a higher mean contribution of solid waste then other hospitals. This can be

TABLE 50

CONTRIBUTIONS OF SOLID WASTE, BY WEIGHT, FOR RANGES OF NUMBER OF TRAINEES RESIDING AT THE HOSPITAL

Range in Number of Trainees Residing at Hospital	Number of Hospitals	Mean Lbs Per Day Per Patient	Estimated Standard Deviation
0	56	8.3	2.0
1 - 49	9	8.5	2.0
50 - 99	9	9.6	2.5
100 - 149	3	11.5	1.9
150 - 199	1	14.2	-
200 - 249	2	11.9	6.1
Total:	80		

seen from the following summary, which lists mean pounds per day per patient, developed from data for the full-scale stage of the study:

	N	Mean Lb/Day/ Patient	Estimated Standard Deviation
Neither state license nor accreditation	1	5.0	-
State license only	4	7.0	1.0
Accreditation only	15	7.1	1.3
State license and accreditation	60	9.3	2.4
Total:	80		

Hospitals with both a state license and accreditation showed significantly more waste per patient than those with accreditation only (P less than 0.001).

Comparison with Regulations for Hospitals Visitors. Mean pounds of solid waste per day per patient were calculated for ranges of number of hours per day when visiting was permitted. The visiting hours considered were those for general medical-surgical patients. Results are as follows (full-scale study):

Range of Number of Hours per Day When Visiting Permitted	Number of Hospitals	Mean Lb/Day/ Patient	Estimated Standard Deviation
1 - 4	35	8.74	2.3
5 - 9	31	8.68	2.8
10 and more	14	8.75	1.6
Total:	80		

The data from the second stage of the research suggested the possibility of a relationship between visiting hours and quantity of solid waste. However, data from the full-scale stage of the study, as summarized above, did not indicate any relation. Similarly, hospitals with no limit on the number of persons permitted to visit a patient at one time were not significantly different in solid waste contribution from other hospitals. This can be seen from the following summary, which lists mean pounds of solid waste per day per patient for the two categories:

	N	Mean Lb/Day/ Patient	Est.S.D.
No limit on number of visitors	12	9.1	2.1
Limit of two visitors	64	8.7	2.5

Note that a few values did not fit into these two categories.

Regressions with Multiple Independent Variables. Attempts were made to correlate quantities of solid waste per patient to several independent variables in the same equation. In the initial attempt the weight of solid waste per patient was correlated with patient census, presence of a hospital controlled nursing school, radioisotope utilization, laboratory research, and location in a standard metropolitan statistical area. The following equation was found:

(8) $y_3 = 7.2 + 0.0031x_2 + 0.15x_3 - 0.031x_4 + 1.3x_5$
$+ 0.93x_6$

y_3 = pounds of solid waste per day per patient.

x_2 = patient census, including newborn, on day of survey.

x_3 = one if there is a hospital controlled nursing school, and zero if there is not.

x_4 = one if there is radioisotope utilization at the hospital, and zero if there is not.

x_5 = one if there is laboratory research at the hospital, and zero if there is not.

x_6 = one if the hospital is located in a standard metropolitan statistical area, and zero if it is not.

This regression was performed with data from the full-scale research, and a correlation coefficient of 0.51 was obtained. This equation could be viewed as indicating the increments of solid waste contribution associated with various conditions. For example, the presence of a nursing school was associated with over 0.5 lb per day per patient more waste, and research with almost 1.3 lb per day per patient. It was notable that location in a standard metropolitan statistical area accounted for approximately 1.0 lb per day per patient, particularly since such location was only poorly related to patient census (correlation coefficient of 0.30). Correlation coefficients were determined for the various combinations of independent variables. Presence of nursing school, radioisotope utilization, and laboratory research were related to patient census with correlation coefficients of 0.38, 0.46, and 0.57. Other correlation coefficients for pairs of independent variables ranged from 0.13 to 0.42.

Linear regressions relating contribution of solid waste per patient, by weight, were performed with two other groups of variables. One regression related contribution of solid waste to patient census, number of staff and trainees, number of staff and trainees residing at the hospital, and number of outpatient visits per year. A correlation coefficient of 0.60 was found, and information was also obtained regarding which variables were related most highly to contribution of solid waste per patient. The third linear regression using several independent variables related the contribution of solid waste per patient, by weight, to hospital bed capacity, possession of accreditation and a state license, number of surgical procedures and live births per year, number of operating rooms, community population, and the presence of a psychiatric inpatient unit, pathology laboratory, and cobalt therapy facility. The correlation coefficient obtained was 0.64.

The following summarizes the correlation between the dependent variable, pounds per patient per day, and various individual factors considered in the research:

Factor	Correlation Coefficient
Number of operating rooms	0.19
Nursing school	0.25
Radioisotope utilization	0.28
Psychiatric inpatient unit	0.29
Pathology laboratory	0.29
Population of community	0.30
Presence in a standard metropolitan statistical area	0.32
Number of employees residing at the hospital	0.34
Cobalt therapy	0.36
Number of live births per year	0.36
Research	0.40
Accreditation and state license	0.41
Patient census on day of survey	0.43
Bed capacity	0.45
Outpatient visits per year	0.45
Number of trainees residing at the hospital	0.45
Number of trainees	0.48
Number of surgical procedures per year	0.50
Number of employees	0.52

All of the listed correlation coefficients except the first one are significantly greater than zero, considering the 95 percent confidence level. However, no statements are made regarding actual differences among the listed correlation coefficients.

To further analyze these data, all independent variables having correlation coefficients of 0.40 or greater were included in one regression. Preliminary analysis permitted the elimination of several independent variables which were very highly correlated with other such variables. The final equation was as follows:

$$(9) \quad y_3 = 6.7 - 0.0057x_1 + 0.85x_3 + 0.0051x_7 + 0.015x_8 + 0.010x_9 + 1.7x_{10} + 0.00028x_{11}$$

y_3 = pounds of solid waste per day per patient.

x_1 = bed capacity, including newborn bassinets.

x_3 = one if there is laboratory research at the hospital, and zero if there is not.

x_7 = number of trainees.

x_8 = number of trainees residing at the hospital.

x_9 = number of outpatient visits per year, in thousands.

x_{10} = one if the hospital possesses a current state license and is also accredited by the Joint Commission, and zero otherwise.

x_{11} = number of surgical procedures per year.

The correlation coefficient for this regression is 0.71.

Quantities of Solid Waste Per Admission

Data for contribution of solid waste per admission were developed as a possible alternative to contribution per patient. In the case of a waste component which is generated in proportion to the number of patient days, such a parameter would be reliable. Other waste, such as that from single-patient disposable articles, would tend to justify use of the parameter, quantity of solid waste per admission.

For the full-scale stage of the research, the mean contribution of waste, by weight, was 71.7 lbs per admission, and the 95 percent confidence interval was 64.5 to 78.9 lbs per admission. The mean for waste volume was 16.1 cu ft per admission, with a 95 percent confidence interval of 14.2 to 18.0 cu ft per admission. Means derived from the second stage of the study were 71.2 lbs per admission and 14.6 cu ft per admission. The ranges in quantity of waste per admission were as follows:

	Range for Lbs Per Admission	Range for Cu Ft Per Admission
Second Stage	41 to 131	4 to 23
Full-Scale Stage	27 to 173	1 to 44

The ranges were broader than those for quantities of solid waste per patient per day.

The relation between contributions of solid waste per admission and hospital bed capacity and use was investigated. Tables 51 and 52 list mean quantities by weight and volume of solid waste, respectively, per admission, for ranges of bed capacity. These data appear to indicate an increase in quantity of waste per admission as bed capacity increases.

Linear regressions of quantity of solid waste per admission versus patient census were performed on both a weight and a volume basis. The correlation coefficients which were found using data from the 80 hospitals in the full-scale stage of the study were as follows:

Regression	Correlation Coefficient
Pounds per admission versus census	0.44
Cubic feet per admission versus census	0.41

TABLE 51

WEIGHT OF SOLID WASTE PER ADMISSION FOR RANGES OF HOSPITAL BED CAPACITY

Range of Hospital Bed Capacity	Second Stage Mean			Full-Scale Study Mean		
	N	Lb/ Admission	Est. S.D.	N	Lb/ Admission	Est. S.D.
50 - 99	3	51	27	18	55	21
100 - 199	6	67	34	27	62	34
200 - 299	5	88	22	10	83	27
300 - 399	8	68	15	9	83	35
400 - 499	-	-	-	8	78	26
500 - 599	3	80	7	4	78	6
600 - 699	-	-	-	3	119	20
700 and more	-	-	-	1	140	-
Total:	25			80		

TABLE 52

VOLUME OF SOLID WASTE PER ADMISSION FOR RANGES OF HOSPITAL BED CAPACITY

Range of Hospital Bed Capacity	Second Stage Mean			Full-Scale Study Mean		
	N	Lb/ Admission	Est. S.D.	N	Lb/ Admission	Est. S.D.
50 - 99	3	10	7	18	13	6
100 - 199	6	15	5	27	13	8
200 - 299	5	19	4	10	19	7
300 - 399	8	13	3	9	18	11
400 - 499	-	-	-	8	17	8
500 - 599	3	17	1	4	15	4
600 - 699	-	-	-	3	32	12
700 and more	-	-	-	1	34	-
Total:	25			80		

The correlation coefficient obtained for pounds per admission was slightly higher than the value, 0.43, obtained for the corresponding regression with pounds per day per patient. However, the value obtained in the regression between cubic feet per admission and census (0.41) was much higher than the correlation coefficient obtained in the regression of cubic feet per day per patient versus census (0.32).

The results of the analysis of data on quantities of waste per admission were considered encouraging. It was judged, however, that since numbers of admissions were generally small (mean of 25 per day for the full-scale stage of the study), a variation of only a few admissions could account for a very large percent of difference in results. To counteract this, data were recalculated, using as a basis the mean of admissions and discharges for the survey day at each hospital visited. However, no improvement in correlation was obtained.

Types of Hospital Solid Waste

An important aspect of the study was the development of data on the relative quantities of the various types of hospital solid waste. Table 53 indicates the mean percents of various types of waste, and the estimated standard deviations, as developed in the full-scale stage of the study. It can be seen that combustible rubbish accounted for a mean of one-half of the

TABLE 53

TYPES OF SOLID WASTES IN HOSPITAL REFUSE

Type of Solid Waste	Number of Hospitals	Mean % of Total Weight of Solid Waste*	Estimated Standard Deviation
Biological material†	8	0.15	0.48
Combustible rubbish	80	50	12
Construction and Demolition waste†	5	0.22	1.1
Garbage‡	75	28	11
Noncombustible rubbish	75	9.2	5.8
Yard waste†	6	0.35	1.6
Mixed, other and unknown	28	12	19

*Calculated using 80, the total number of full-scale surveys, as the denominator.

†Incomplete data.

‡Includes estimates of waste descharged to grinders.

total weight of solid waste, garbage for approximately 28 percent, and noncombustible rubbish for 9 percent. Most of the values indicated for garbage include estimates of the weight of food waste discharged to grinders. Construction and demolition waste, as shown in the noted table, includes only incidental amounts which were intimately associated with other types of waste. It was necessary to eliminate from the comparison certain very large amounts of construction and demolition waste found at a few hospitals where there was extensive construction and demolition activity. The weights of such construction and demolition waste were so large in a few instances as to yield misleading results in data analysis. Further, biological material and yard waste were measured separately at only a few institutions. Such waste was weighed as part of mixed waste at other hospitals.

An attempt was made to relate the composition of the solid waste to the bed capacity of the hospitals. Table 54, which shows data from the full-scale study, indicates a general increase in the percent of combustible rubbish in the waste, although differences are not significant at the 95 percent confidence level. No trends were found for other types of hospital solid waste. This is in contrast to the American Public Health Association report, which indicated differences in the proportions of various waste types associated with hospital bed capacity.[11]

TABLE 54

MEAN PERCENT OF COMBUSTIBLE RUBBISH IN SOLID WASTE FOR RANGES OF HOSPITAL BED CAPACITY

Range of Hospital Bed Capacity	Number of Hospitals	Mean % Combustible Rubbish in Solid Waste	Estimated Standard Deviation
50 - 99	18	48	11
100 - 199	27	50	11
200 - 299	10	53	10
300 - 399	9	51	12
400 - 499	8	39	18
500 - 599	4	55	7
600 - 699	3	59	6
700 and more	1	76	-
Total:	80		

Densities of Types of Hospital Solid Wastes

Density of Combustible Rubbish. Among the types of solid wastes considered in the research, densities could be estimated for only combustible rubbish and noncombustible rubbish. The mean density of combustible rubbish found in the full-scale stage of study was 2.89 lbs per cu ft, and the range in values was 1.6 to 4.3 lbs per cu ft. Table 55 indicates frequency counts for numbers of results found for various ranges of density of combustible rubbish. The distributions are quite similar for for the two.

Density of Noncombustible Rubbish. Noncombustible rubbish was found to have a mean, considering 75 observations in the full-scale study, of 7.55 lbs per cu ft. Similarly, data from the second stage of the study indicated a mean of 8.49 lbs per cu ft.

Table 56 indicates frequency counts for ranges of density of noncombustible rubbish. The overall range in density was considerably greater for noncombustible rubbish. The actual range in density for noncombustible rubbish was 2.1 to 17.3 lbs per cu ft for observations in the full-scale stage of the study, and 5.1 to 12.2 lbs per cu ft for data in the second stage of the study.

TABLE 55

DENSITY OF COMBUSTIBLE RUBBISH

Range of Lbs Per Cu Ft	Second Stage Number	Second Stage %	Full-Scale Stage Number	Full-Scale Stage %
No data	2	8	1	1
1.5 - 1.9	-	-	6	7
2.0 - 2.4	2	8	14	17
2.5 - 2.9	9	36	24	30
3.0 - 3.4	7	28	21	26
3.5 - 3.9	2	8	11	14
4.0 - 4.4	2	8	3	4
4.5 - 4.9	1	4	-	-
Total:	25	100%	80	99%

TABLE 56

DENSITY OF NONCOMBUSTIBLE RUBBISH

Range of Lbs Per Cu Ft	Second Stage		Full-Scale Stage	
	Number	%	Number	%
No Date	3	12	5	6
2.0 - 2.9	-	-	1	1
3.0 - 3.9	-	-	2	3
4.0 - 4.9	-	-	10	13
5.0 - 5.9	2	8	10	13
6.0 - 6.9	2	8	14	17
7.0 - 7.9	6	24	8	10
8.0 - 8.9	3	12	12	15
9.0 - 9.9	4	16	2	3
10.0 - 10.9	4	16	9	11
11.0 - 11.9	-	-	1	1
12.0 - 12.9	1	4	3	4
13.0 and greater	-	-	3	4
Total:	25	100%	80	101%

Sources of Solid Waste Within the Hospital

Table 57 summarizes data on the mean percent of solid waste generated in various areas of the hospital. Data are presented for only the full-scale stage of the research. The table shows the importance of solid waste from dietary facilities, accounting for an average of almost one-half of the weight of solid waste. Other important sources of solid wastes are general nursing stations, averaging approximately 20 percent; surgery, averaging almost 5 percent; maternity, averaging almost 4 percent; and offices and laboratories, each averaging approximately 2 percent. The remaining waste originated in smaller proportions from many other areas of the hospitals.

Variation in Source of Solid Waste Related to Bed Capacity. Mean percents of the total weight of solid wastes were compared for hospitals with fewer than 200 beds and hospitals with 200 beds or more. Data for the full-scale stage of the study are summarized in Table 58. The smaller hospitals appeared to have generated higher mean percents of the solid waste in basic facilities, including central supply, dietary, maternity, general nursing stations, storerooms, surgery, and x-ray. Larger hospitals appeared to have higher mean percents of waste generated in emergency, hospitality shop, intensive care, laboratories, pediatric care, and pharmacy. However, the differences are

TABLE 57

SOURCES OF SOLID WASTE WITHIN THE HOSPITAL

Source	Number of Observations	Mean %* of Total Solid Waste Weight	Estimated Standard Deviation
Administrative and Other Offices	47	1.6	1.9
Central Supply	32	0.84	1.3
Teaching Facilities	2	0.03	0.2
Construction and Demolition	5	0.22	1.1
Dietary Facilities	80	49	9.6
Emergency	30	0.82	1.5
Extended Care	7	0.54	2.3
Grounds	7	0.36	1.6
Hospitality Shop	28	0.94	1.8
Housekeeping	8	0.13	0.40
Intensive Care	15	0.46	1.2
Isolation	10	0.26	0.84
Laboratories	58	2.1	2.0
Laundry	24	0.46	0.87
Maintenance	16	0.34	0.78
Maternity	54	3.8	3.9
Morgue	2	0.04	0.3
Nursing Stations, General	74	20	9.6
Outpatient Department	7	0.24	0.88
Pediatric Care	25	0.85	1.7
Pharmacy	33	0.74	1.2
Physical Therapy	2	0.05	0.3
Psychiatric Care	5	0.20	1.2
Public Areas	12	0.29	0.84
Residences	20	0.76	1.8
Storerooms	35	1.2	1.9
Surgery	66	4.5	4.3
X-ray	40	1.1	2.5
Mixed, other and Unknown	46	8.3	15

*Calculated using 80, the total number of full-scale surveys, as the denominator.

TABLE 58

WEIGHT OF SOLID WASTE FROM SELECTED SOURCES FOR HOSPITALS LARGER AND SMALLER THAN 200 BEDS

	Mean % of Solid Waste Weight	
Source	Hospitals with Fewer than 200 Beds	Hospitals With 200 Beds or More
Central Supply	1.04	0.57
Dietary Facilities	50.80	46.20
Emergency	0.67	1.03
Hospitality Shop	0.85	1.07
Intensive Care	0.31	0.66
Laboratories	1.78	2.40
Maternity	4.22	3.29
Nursing Stations, General	23.64	15.31
Pediatric Care	0.65	1.11
Pharmacy	0.69	0.80
Storerooms	1.38	0.92
Surgery	4.84	4.14
X-ray	1.24	1.03

significant for only dietary facilities and general nursing stations.

Analysis of Solid Waste Collection Operations Within the Hospital

Number of Loads of Solid Waste Per Day. The mean number of loads of solid waste collected in the hospitals visited was 38 in the second stage of the study, and 27 in the full-scale stage of the study. The range in the second stage of the study was 10 to 92 loads per day, and was 3 to 154 loads per day in the full-scale stage of the study.

Table 59 compares the number of loads of solid waste per day with bed capacity. The data indicate an increase in the number of loads of solid waste per day, ranging from a mean of approximately 15 loads per day for hospitals with fewer than 100 beds to approximately 40 to 50 loads per day for the largest hospitals.

Mean Weight and Volume of Loads of Solid Waste. Data on the frequency with which mean loads of various size were observed are shown in Table 60 for weight, and in Table 61 for volume. Data regarding sizes of loads are summarized in the following:

	Average Weight Load			Average Volume Load		
	N	Mean (Lbs)	Range (Lbs)	N	Mean (Cu Ft)	Range (Cu Ft)
Second Stage	21	37	9 - 85	21	6	2 - 22
Full-Scale Stage	75	48	5 - 185	75	13	3 - 46

TABLE 59

NUMBER OF LOADS OF SOLID WASTE COLLECTED PER DAY, COMPARED WITH BED CAPACITY

Range of Hospital Bed Capacity	Second Stage Mean			Full-Scale Stage Mean		
	N	Loads Per Day	Est. S.D.	N	Loads Per Day	Est. S.D.
No Data	4	-	-	5	-	-
50 - 99	3	17	6	17	16	9
100 - 199	5	34	16	25	22	15
200 - 299	4	40	20	9	24	13
300 - 399	6	49	29	8	28	18
400 - 499	-	-	-	8	31	14
500 - 599	3	39	2	4	35	23
600 - 699	-	-	-	3	35	20
700 and more	-	-	-	1	154	-
Total:	25			80		

TABLE 60

MEAN LOAD OF SOLID WASTE, BY WEIGHT

Mean Load, Range of Lbs	Hospitals Visited			
	Second Stage		Full-Scale Stage	
	Number	%	Number	%
No Data	4	16	5	6
1 - 24	8	32	23	29
25 - 49	7	28	27	34
50 - 74	3	12	11	14
75 - 99	3	12	8	10
100 - 124	-	-	2	3
125 - 149	-	-	3	4
150 - 174	-	-	-	-
175 - 199	-	-	1	1
Total:	25	100%	80	101%

TABLE 61

MEAN LOAD OF SOLID WASTE, BY VOLUME

Mean Load, Range of Cu Ft	Hospitals Visited Second Stage Number	%	Full-Scale Stage Number	%
No Data	4	16	5	6
1 - 4	3	12	9	11
5 - 9	10	40	24	30
10 - 14	5	20	16	20
15 - 19	1	4	12	15
20 - 24	2	8	6	7
25 - 29	-	-	4	5
30 - 34	-	-	2	3
35 - 39	-	-	1	1
40 and more	-	-	1	1
Total:	25	100%	80	99%

Comparison Between Mean Weight of Loads of Solid Waste and Bed Capacity. Tables 62 and 63 summarize data on mean weight and volume of loads of solid waste compared with ranges of bed capacity for hospitals considered in the study. The mean load for the hospitals with the greatest bed capacities was approximately five times as large as that for the smallest hospitals, considering either weight or volume. This suggests that many hospitals, particularly smaller ones, might readily increase the efficiency of solid waste collection by increasing the size of loads of waste.

Maximum Weight and Volume of Loads of Solid Waste. The means of the maximum loads were 137 lbs and 33 cu ft for the hospitals in the full-scale stage of the study, and 144 lbs and 30 cu ft for the hospitals of the second stage of the study. Tables 64 and 65 indicate frequency counts for ranges of size of maximum load with respect to weight and volume. The data indicate very wide ranges in size of the maximum load as summarized in the following:

	Range in Size of Maximum Load	
Study	Weight (Lbs)	Volume (Cu Ft)
Second Stage	30 to 270	6 to 64
Full-Scale	11 to 538	5 to 132

The data on the size of the maximum load again suggest that there is potential for improving the efficiency of collection operations

TABLE 62

MEAN LOAD OF SOLID WASTE, BY WEIGHT, FOR RANGES OF HOSPITAL BED CAPACITY

Range of Hospital Bed Capacity	Second Stage			Full-Scale Stage		
	N	Mean Load, Lbs	Est. S.D.	N	Mean Load, Lbs	Est. S.D.
No Data	4	-	-	5	-	-
50 - 99	3	19	11	16	20	12
100 - 199	5	25	20	26	33	18
200 - 299	4	39	30	9	46	25
300 - 399	6	49	30	8	61	29
400 - 499	-	-	-	8	98	50
500 - 599	3	53	28	4	83	35
600 - 699	-	-	-	3	95	43
700 and more	-	-	-	1	96	-
Total:	25			80		

TABLE 63

MEAN LOAD OF SOLID WASTE, BY VOLUME, FOR RANGES OF HOSPITAL BED CAPACITY

Range of Hospital Bed Capacity	Second Stage			Full-Scale Stage		
	N	Mean Load, Cu Ft	Est. S.D.	N	Mean Load, Cu Ft	Est. S.D.
No Data	4	-	-	5	-	-
50 - 99	3	4	2	16	6	3
100 - 199	5	6	4	26	9	5
200 - 299	4	9	7	9	13	6
300 - 399	6	12	7	8	17	9
400 - 499	-	-	-	8	24	12
500 - 599	3	14	5	4	17	1
600 - 699	-	-	-	3	26	8
700 and more	-	-	-	1	27	-
Total:	25			80		

TABLE 64

MAXIMUM LOAD OF SOLID WASTE, BY WEIGHT

Maximum Load, Range of Lbs	Hospitals Visited Second Stage Number	%	Full-Scale Stage Number	%
No Data	4	16	8	10
1 - 49	4	16	11	14
50 - 99	5	20	22	27
100 - 149	1	4	15	19
150 - 199	3	12	8	10
200 - 249	5	20	6	7
250 - 299	3	12	4	5
300 - 349	-	-	3	4
350 - 399	-	-	1	1
400 - 449	-	-	-	-
450 - 499	-	-	1	1
500 - 549	-	-	1	1
Total:	25	100%	80	99%

TABLE 65

MAXIMUM LOAD OF SOLID WASTE, BY VOLUME

Maximum Load, Range of Cu Ft	Hospitals Visited			
	Second Stage		Full-Scale Stage	
	Number	%	Number	%
No Data	4	16	8	10
1 - 9	2	8	5	6
10 - 19	5	20	17	21
20 - 29	3	12	21	26
30 - 39	5	20	11	14
40 - 49	4	16	3	4
50 - 59	1	4	5	6
60 - 69	1	4	4	5
70 - 79	-	-	2	3
80 - 89	-	-	-	-
90 - 99	-	-	2	3
100 and more	-	-	2	3
Total:	25	100%	80	101%

within the hospital by increasing the size of loads of solid waste.

Peak Hour for Collection of Solid Waste in the Hospital. The solid waste collection at hospitals was such that the peak hour was generally quite pronounced. The peak hour with regard to weight of solid waste averaged 26.7 percent of the total for the day in the full-scale stage of the study, and 23.3 percent for the second stage of the study. Peak hours with regard to volume of solid waste were similar, accounting for 26.7 percent of the day's total of waste for the full-scale study, and 21.8 percent for the second stage of the endeavor. The most frequently occurring time for the peak hour was 2:00 to 3:00 p.m. Tables 66 and 67 list frequency counts for ranges of percent of total solid waste weight and volume, respectively, collected during the peak hours. The distributions were similar for the two stages of the study, and the ranges in peak hours were rather wide. The ranges in percent of waste collected during the peak hour were as follows:

	Range in % of Waste Collected	
	With Regard to Weight	With Regard to Volume
Second Stage	16 to 50	12 to 39
Full-Scale Stage	8 to 51	12 to 65

Comparison of Percent of Waste Collected During Peak Hour With Bed Capacity. Mean percents of solid waste collected during

TABLE 66

PERCENT OF TOTAL SOLID WASTE WEIGHT COLLECTED DURING PEAK HOUR

Range of Total Solid Waste Weight Collected During Peak Hour, %	Hospitals Visited			
	Second Stage		Full-Scale Stage	
	Number	%	Number	%
No Data	3	12	10	13
1 - 9	-	-	1	1
10 - 19	8	32	19	24
20 - 29	12	48	29	36
30 - 39	1	4	11	14
40 - 49	-	-	9	11
50 - 59	1	4	1	1
Total:	25	100%	80	100%

TABLE 67

PERCENT OF TOTAL SOLID WASTE VOLUME COLLECTED DURING PEAK HOUR

Range of Total Solid Waste Volume Collected During Peak Hour, %	Hospitals Visited			
	Second Stage		Full-Scale Stage	
	Number	%	Number	%
No Data	3	12	10	13
1 - 9	-	-	-	-
10 - 19	7	28	23	29
20 - 29	13	52	23	29
30 - 39	2	8	14	17
40 - 49	-	-	8	10
50 - 59	-	-	1	1
60 - 69	-	-	1	1
Total:	25	100%	80	100%

the peak hour were calculated for ranges of bed capacity. The results are shown in Tables 68 and 69. The data indicated a general decline in the percent of solid waste collected during the peak hour as hospital bed capacity increased. The differences between successive mean were not significantly different at the 95 percent confidence level in most instances. However, the effect of hospital size can be verified by comparing mean percents of solid waste collected during the peak hour for hospitals having fewer than 200 beds with corresponding values for hospitals having 200 beds or more. This is summarized in the following:

		Mean % Collected During Peak Hour	
Stage of Research	Description of Peak Hour	Hospitals with Fewer than 200 Beds	Hospitals with 200 Beds or More
Second Stage	Total Weight	28.6	20.3
	Total Volume	25.8	19.5
Full-Scale Stage	Total Weight	30.5	21.2
	Total Volume	30.3	21.6

The differences above are significant at the 95 percent confidence level, with probabilities of obtaining variations as large or larger, in the absence of true differences, being 0.02, 0.02, less than 0.001, and less than 0.001, respectively, for the comparisons listed.

Peak Hour for Collection of Combustible Rubbish. Data for peak hour of solid waste collection with regard to combustible rubbish were similar. The mean, considering weight, was 27.7

TABLE 68

MEAN PERCENTS OF TOTAL SOLID WASTE COLLECTED DURING PEAK HOUR, BY WEIGHT, FOR RANGES OF HOSPITAL BED CAPACITY

Range of Hospital Bed Capacity	Second Stage			Full-Scale Stage		
	N	Mean % of Total Weight	Est. S.D.	N	Mean % of Total Weight	Est. S.D.
No Data	3	-	-	10	-	-
50 - 99	3	35	13	17	31	12
100 - 199	5	25	12	24	30	13
200 - 299	4	20	9	7	20	11
300 - 399	7	20	8	8	18	7
400 - 499	-	-	-	8	28	13
500 - 599	3	21	3	3	19	9
600 - 699	-	-	-	2	16	9
700 and more	-	-	-	1	17	-
Total:	25			80		

TABLE 69

MEAN PERCENTS OF TOTAL SOLID WASTE COLLECTED DURING PEAK HOUR, BY VOLUME, FOR RANGES OF HOSPITAL BED CAPACITY

	Second Stage			Full-Scale Stage		
Range of Hospital Bed Capacity	N	Mean % of Total Volume	Est. S.D.	N	Mean % of Total Volume	Est. S.D.
No Data	3	-	-	10	-	-
50 - 99	3	29	8	17	30	12
100 - 199	5	24	11	24	30	15
200 - 299	4	21	9	7	20	11
300 - 399	7	19	8	8	22	10
400 - 499	-	-	-	8	26	12
500 - 599	3	20	6	3	17	9
600 - 699	-	-	-	2	11	9
700 and more	-	-	-	1	16	-
Total:	25			80		

percent of the combustible rubbish for the full-scale study, and 24.9 percent for the second stage of the study. The ranges for the percent of the total combustible rubbish collected during the peak hour were 12 to 71 percent for the full-scale stage and 12 to 49 percent for the second stage of the study. As with total waste quantities, the portion of the waste collected during the peak hour generally decreased with increasing bed capacity.

The peak hour with regard to combustible rubbish should be particularly significant at those hospitals incinerating solid waste. Table 70 lists frequency counts for the percent of incinerator rated capacity charged to the unit during the peak hour. From these data, it is apparent that approximately 25 to 30 percent of the hospital incinerators for which data were available were overloaded during the peak hour. This may not be a reliable indication of the percent of hospital incinerators which are overloaded since lack of data on rated capacity prevented performing the comparison for most incinerators.

Disposition of Hospital Solid Waste

Table 71 lists methods used for the disposal of hospital solid waste. In the full-scale stage of the study, incineration at the hospital was used for a mean of 35 percent of the waste; grinding with disposal to the sewerage system, approximately 20 percent; municipal incineration, approximately 3 percent;

TABLE 70

PERCENT OF INCINERATOR RATED CAPACITY CHARGED DURING PEAK HOUR

Incinerator Rated Capacity, Range of %	Hospitals Visited			
	Second Stage		Full-Scale Stage	
	Number	%	Number	%
1 - 24	-	-	3	10
25 - 49	2	25	7	24
50 - 74	3	37	7	24
75 - 99	1	13	4	14
100 - 124	1	13	6	21
125 and greater	1	13	2	7
Total:	8	101%	29	100%

TABLE 71

DISPOSITION OF HOSPITAL SOLID WASTE

Method of Solid Waste Disposal	Second Stage of Study			Full-Scale Stage of Study		
	N	Mean %*	Range of %†	N	Mean %*	Range of %†
Incineration at the hospital	13	22	16- 63	63‡	35	3- 89
Grinding	19	20	14- 39	63‡	21	1- 47
Municipal incineration	-	-	-	7	2.9	3-100
Sanitary landfill	4	5.6	8- 77	24	15	3- 98
Dumping	13	24	11-100	49	21	6-100
Hog feeding	4	2.5	5- 27	13	3.7	4- 40
Mixed, other, and unknown	10	25	1-100	4	1.2	2- 45

*Means include values of zero.

†Ranges include only hospitals for which waste was measured for indicated method of disposal.

‡Excludes certain instances in which method was used, at least occasionally, but no waste was measured.

sanitary landfill, 15 percent; dumping, approximately 20 percent; and hog feeding, approximately 4 percent. The high percent of waste categorized as mixed, other, and unknown in the second stage of the study is explained by the fact that this aspect of the research had not been fully developed at the time these data were collected.

Attempts were made to relate method of solid waste disposition to bed capacity. There appeared to be very little difference between the methods of disposal used by hospitals of different sizes. This can be seen from the following summary of data developed in the full-scale stage research:

	Mean % of Solid Waste	
Method of Disposal	Hospitals with Fewer than 200 Beds	Hospitals with 200 Beds or More
Incineration at the hospital	33	35
Grinding	21	20
Municipal incineration	3.1	2.7
Sanitary landfill	16	14
Dumping	20	23
Hog feeding	5.6	1.2
Mixed, other, and unknown	1.1	3.5

The larger percent of solid waste disposed of by hog feeding at the smaller hospitals is the most interesting difference apparent in these data, although even this difference is not significant (P = 0.1).

VII. DISCUSSION, SUMMARY, AND CONCLUSIONS

Limitations of the Study

As already described, the study was limited to nongovernmental, nonprofit, general hospitals having 50 or more adult beds. After the orientation stage of the research, university teaching hospitals were excluded from consideration. The findings of the research must be limited to hospitals of the same type as studied. Hospitals of other types may differ from those studied in numerous ways, including bed capacity, length of stay, nature and extent of facilities, age and other characteristics of patients, medical conditions which are treated, and other characteristics.

As discussed in a previous chapter, estimates were included in waste quantities to account for food waste discharged to grinders. The estimates were included in such data as total quantity of solid waste generated per day, contribution of solid waste per day per patient, contribution of solid waste per admission, and breakdowns according to type of waste, source within the hospital, and method of disposal. The accuracy of these data is limited by the accuracy of the estimates. The estimates were based on a small number of results and were not highly accurate.

The manner in which visits to hospitals were scheduled places certain limitations on the data. In the full-scale stage of the research, visits were scheduled for one day. The day of the week was generally determined by the demands of the particular hospital and the practical requirements of travel. However, inquiry at hospitals nearly always brought the opinion that the quantity of solid waste varied during the course of the week. The pattern of the variation differed in comments received at the hospitals, and was said to be related to changes in patient census through the course of the week, days of the week on which supplies were received, number of surgical procedures performed on various days, and other factors. It is an important limitation that the experimental design did not provide for evaluation of the effect of day of the week on which the hospitals were visited. Therefore, although no significant differences were found in the weight of solid waste per patient on the different days of the week, the study revealed no conclusive evidence of the absence of such differences.

Similar comments apply to the month during which surveys were performed. Hospital visits were not randomly allocated to the 12 months, and there was a considerable variation in the numbers of surveys performed during the various months. It is reasonable that quantity of solid waste might vary with the month, considering such possible effects as larger amounts of yard trimmings and construction waste during summer months, and larger amounts of packaging material during periods of holidays. In fact, research data did indicate that mean quantities of solid waste per patient for two particular months appeared significantly higher than for other months. However, additional study of this effect is needed.

The month of the year during which hospitals were visited had geographic bias. That is, hospitals in particular census regions were visited during particular months. Therefore, although the data did appear to indicate that hospitals located in certain census regions had mean contributions of solid waste significantly different from the others, more study of the effect of area of the country is needed.

Discussion of Findings of the Research

Data indicated that hospitals visited during the full-scale stage of the research were much like the entire population of hospitals of similar type, in every characteristic for which comparison was made. Included were geographic distribution, accreditation, presence of selected facilities and services, presence of selected educational programs, distribution of bed capacity, numbers of outpatient visits and live births per year, and number of employees. This similarly tended to support the validity of findings based on the full-scale stage of the study. Hospitals visited during the second stage of the research showed lesser resemblance to the population of all hospitals of similar type. Although the second stage hospitals were much like the population of similar hospitals with regard to geographic distribution and accreditation, these hospitals more frequently utilized radioisotopes (72 percent of hospitals in second stage sample versus 48 percent for all hospitals of similar type) and radium therapy (68 percent versus 51 percent); participated in educational programs more frequently, including medical residency (48 percent versus 28 percent), medical internship (44 percent versus 23 percent), medical school affiliation (32 percent versus 11 percent), and hospital controlled nursing school (32 percent versus 25 percent); averaged fewer ourpatient visits per year (10,000 versus 18,200); and had more live births per year (1,200 versus 880). The explanation is that the second stage of the research was a pilot study, and hospitals were purposively selected for inclusion.

Data regarding four of the variables considered in the research were plotted on normal probability paper to evaluate whether a normal probability model adequately described the observations. The variables considered were (1) pounds of waste per day per patient, (2) cubic feet of waste per day per patient, (3) total pounds of waste generated per day, and (4) total cubic feet of waste generated per day. The data for the first variable, pounds per day per patient, most nearly approximated a straight line. However, the data were described better by two straight lines having slightly differing slopes, with intersect at approximately the median. For the other three variables, the plotted data could be adequately described in each case by two intersecting straight lines with substantially differing slopes. This analysis appeared to indicate that each of the variables analyzed in this manner could be thought of as two normally distributed variables, particularly the latter three listed.

A difference was found between the results of two linear regressions which both used hospital bed capacity as the independent variable. A high correlation coefficient, 0.94, was found in relating the total weight of solid waste generated per day to bed capacity, while a much lower correlation coefficient, 0.45, was found in performing the regression for weight of solid waste per day per patient. Both coefficients indicate real correlations. The difference in the correlation coefficients can be understood by considering that there are two reasons that total quantity of solid waste generally increases with increasing bed capacity, these being (1) increase in the contribution of solid waste per patient, and (2) increase in the number of patients at the hospital.

A considerable number of analyses were performed to determine what factors were related to contribution of solid waste per patient per day, by weight. Preliminary analysis was performed using Student's t-test to evaluate the significance of differences in contributions of solid waste for various groups of hospitals. Tests were performed using a 5 percent level of significance. That is, tests were performed such that the probability of a type I error, rejecting the hypothesis of no difference when there was actually no difference between the groups, was 5 percent. Calculation of the probability of a type II error was not considered in the research, since failure to find a significant difference was not cited as support of the null hypothesis. A type II error is the acceptance of the hypothesis of no difference when a difference actually exists.

Variables which were shown by testing of hypotheses to be related to contribution of solid waste per day per patient were studied further by linear regression with multiple independent variables. Analysis in this manner permitted determination of the correlation coefficient for each independent variable. Variables having correlation coefficients with respect to the dependent variable under consideration as high as that for bed capacity or higher were number of outpatient visits per year, number of trainees residing at the hospital, number of trainees, number of surgical procedures per year, and number of employees. No claim is made that these correlation coefficients are significantly higher than that for bed capacity.

In further study, all independent variables having a correlation coefficient of 0.4 or greater were included in one linear regression. The correlation matrix which was one product of this analysis is shown in Table 72. It can be seen that pairs of independent variables were highly correlated in a number of instances. It was possible to lessen the number of independent variables without greatly reducing the multiple correlation coefficient.

The variables found significantly related to weight of solid waste generated per day per patient included certain ones relating to (1) hospital facilities and services, (2) participation in educational activity, (3) number of persons employed or receiving treatment at the hospital, (4) measures of activity at the hospital (for example, number of surgical procedures per year), and (5) other characteristics. It is particularly interesting that significant correlations were found for population of the community, presence in a standard metropolitan statistical area, and the hospital both possessing a state license and being accredited. None of these variables was highly correlated with hospital bed capacity (correlation coefficients of 0.18, 0.30, and 0.15). One may speculate that these effects were related to such factors as more sophisticated medical care, more extensive facilities, greater utilization of the hospital, and other conditions.

A distinction should be made between contribution of solid waste per day per patient and per bed. Contributions of solid

TABLE 72

CORRELATION MATRIX FOR VARIABLES MOST HIGHLY RELATED TO CONTRIBUTION OF SOLID WASTE PER DAY PER PATIENT

	Lbs Per Day Per Patient	Patient Census	Research	Number of Employees	Number of Trainees
Pounds per day per patient	1.00	-	-	-	-
Patient census	0.43	1.00	-	-	-
Research	0.40	0.57	1.00	-	-
Number of employees	0.52	0.97	0.59	1.00	-
Number of trainees	0.48	0.75	0.42	0.81	1.00
Number of trainees residing at the hospital	0.45	0.60	0.35	0.63	0.79
Number of outpatient visits per year	0.45	0.30	0.43	0.36	0.31
State license and accreditation	0.41	0.15	0.11	0.20	0.14
Bed capacity	0.45	0.99	0.56	0.97	0.76
Number of surgical procedures per year	0.50	0.89	0.50	0.85	0.60

TABLE 72 (continued)

	Number of Trainees Residing at the Hospital	Number of Outpatient Visits Per Year	State License and Accreditation	Bed Capacity	Number of Surgical Procedures Per Year
Pounds per day per patient	-	-	-	-	-
Patient census	-	-	-	-	-
Research	-	-	-	-	-
Number of employees	-	-	-	-	-
Number of trainees	-	-	-	-	-
Number of trainees residing at the hospital	1.00	-	-	-	-
Number of outpatient visits per year	0.23	1.00	-	-	-
State license and accreditation	-0.034	0.13	1.00	-	-
Bed capacity	0.61	0.34	0.15	1.00	-
Number of surgical procedures per year	0.49	0.39	0.25	0.91	1.00

waste per bed might be more suitable for design of new hospitals since actual occupancy might then be uncertain. The two variables are related to percent occupancy, as already noted. Hospitals of similar bed capacity can generate substantially different quantities of solid waste per day if the occupancies differ considerably. The literature revealed use of both quantities of waste per patient and per bed. The difference between these variables should be remembered in order to avoid confusion.

The bed capacity of the hospital appeared to be related to a number of the variables considered in the study. For certain variables, comparisons were made between hospitals having fewer than 200 beds and those having 200 beds or more. The smaller hospitals had a significantly higher percentage of solid waste from dietary facilities (51 percent versus 46 percent) and from general nursing stations (24 percent versus 15 percent). These differences may reflect the greater relative importance of these basic facilities at smaller hospitals, where certain specialized facilities are less frequently encountered than in larger hospitals. The number of loads of solid waste collected each day steadily increased with increasing bed capacity. However, the increase was less than the increase in number of beds, suggesting more efficient collection of solid waste in larger institutions. The mean weight and volume of loads of waste also increased with increasing bed capacity, but appeared to approach limiting values of approximately 90 to 100 lbs and 20 to 25 cu ft per load. The peak hour with regard to waste collection was much more pronounced at smaller hospitals. Using data from the full-scale stage of the study for the peak hour with respect to weight, the means were 30.5 and 21.2 percent of the total for hospitals with fewer than 200 beds and 200 or more beds, respectively.

Expectations for the Future

Projections of contributions of solid waste in the future can be made by comparing data from this study with information in earlier studies. For example, linear projection using data from the American Public Health Association report[11] and from this study would yield a mean of 10.1 lbs of solid waste per day per patient in 1980.

In fact, there is little reason to believe that the increase in solid waste quantity will be linear. Considering such effects as increasing hospital size, increasing variety of facilities and services at hospitals, and increasing use of disposable supplies, it is likely that a substantially greater increase in quantity of solid waste will occur than given in the preceding simple example.

Other changes may be expected with regard to hospital solid waste. There appears to be increasing use of disposable items in many departments of hospitals of a wide range of sizes. In dietary facilities at hospitals, there is an increasing trend toward the purchase of prepared and even portioned foods. Both of these trends suggest an increase in the combustible rubbish content of solid waste, and a decline in the garbage content. Available data indicate that the composition of hospital solid waste may already have changed in this manner, as can be seen from the following:

	% of Total Weight	
Component of Solid Waste	1956	1969
Garbage	46	28
Combustible rubbish	37	50
Noncombustible rubbish	15	9
Other	2	13
Total:	100	100

The data for 1956 are from the report of the American Public Health Association,[11] and the data for 1969 are from the full-scale stage of the present study. The large percent of waste categorized as "other" for the year 1969 was primarily due to a low degree of waste separation at certain of the hospitals visited, particularly those using stationary compactor systems. That is, most of the indicated 13 percent of the total for 1969 was mixed waste. Most of the mixture were combustible rubbish, with smaller amounts of garbage, noncombustible rubbish, and other components also present.

These changes in the composition of hospital solid waste have important implications for disposal from hospitals. A continued decline in the garbage component of the solid waste could mean that grinders discharging to sewerage systems have less usefulness in the dietary facilities of hospitals. A decrease in the amount of garbage generated at hospitals should make it less profitable for farmers to haul away the material for feeding to hogs.

An increase in the fraction of combustible rubbish should mean that density of the solid waste is reduced. This suggests that if hauling into the community is used to dispose of the bulk of a hospital's solid waste, then the use of larger storage receptacles and equipment for volume reduction will be favored. An increase in the combustible rubbish component of hospital solid waste should also mean that larger fractions of solid waste may be suitable for pulping, shredding, grinding for disposal to sewerage systems, and similar processing.

An increase in the combustible rubbish component would raise the possibility of increased future importance for incineration of hospital solid waste. Incineration would also be favored by a decline in the amount of garbage, which is generally more difficult to incinerate than combustible rubbish.

Summary

Description of Research and Hospitals Visited. Research was performed in three stages, an initial orientation study at seven hospitals in the Twin Cities metropolitan area, a second stage study at 25 purposively selected hospitals throughout the nation, and a full-scale study at 80 hospitals throughout the nation. In the second and full-scale stages, the study was limited to nongovernmental, nonprofit, general hospitals, with university teaching hospitals excluded. An additional criterion was that the hospitals have 50 or more adult beds. Data were obtained by interview, observation, and measurement during visits to the hospitals. Visits to hospitals were scheduled for two days in the second stage of the research, and one day in the full-scale stage.

Location and Community Setting of Hospitals Visited. Hospitals were visited in all nine census regions comprising the United States, including 37 different states. The communities where the hospitals were located were in standard metropolitan statistical areas in 60 percent of the instances.

Description of Solid Waste Handling and Disposal Systems. Plastic bags were most frequently used to enclose the solid waste generated at the hospitals, although paper bags, waste loose in receptacles, and other arrangements were also encountered.

Collection of solid waste within the hospitals was usually by push carts, supplemented by carrying waste by hand. More sophisticated mechanical systems were found at only a few hospitals. Gravity chutes were used as part of the solid waste collection system at approximately one-third of the hospitals visited.

Central storage of solid waste was usually outdoors, and frequently involved several types of containers. These included bulk receptacles (57 percent of hospitals), small cans or improvised receptacles (53 percent of hospitals), and even storage without receptacles (6 percent of hospitals). More than one-half of the hospitals visited had multiple storage locations.

Incineration at the hospital was used by a predominate number of institutions. Types of waste which were more frequently incinerated were combustible rubbish and biological material.

Grinding for discharge of waste to the sewerage system was used for garbage at a majority of hospitals visited, and for biological material at a lesser number of hospitals.

Biological material, although most frequently incinerated at the hospital, was also buried, hauled away with other solid waste, used by drug firms in the case of afterbirth material, and disposed of by other methods. Radioactive solid waste was most frequently stored for decay and then disposed of in the manner used for uncontaminated material. Disposable needles caused puncture wounds in personnel handling solid waste at many hospitals.

Waste was hauled away from every hospital visited, with more than one-third of the hospitals served by several haulers. Private haulers served the largest number of hospitals, followed by municipal agencies, the hospital itself, hog farmers, and haulers contracting with the municipality. Disposal was in a municipal facility in most instances, although private disposal sites were also utilized. The waste hauled from the hospital was usually taken to a land disposal site (90 percent of the hospitals visited), with most of these being open dumps.

The housekeeping department usually had primary responsibility for collection of solid waste within the hospital, the maintenance or engineering department usually had primary responsibility for disposal of the waste, and a number of other departments had various responsibilities related to solid waste handling.

A mean of 10 persons was involved, either full- or part-time, in solid waste handling at the hospitals visited. Hospitals generally required only minimal qualifications for housekeeping personnel collecting solid waste.

Quantity of Solid Waste Per Day. The mean amount of solid waste generated at the hospitals visited was nearly one ton per day, or more than 400 cu ft per day. Both the weight and volume of solid waste were highly correlated with bed capacity, the quantity of solid waste increasing linearly with increasing hospital bed capacity.

Contribution of Solid Waste Per Patient. Contributions of solid waste had a mean of nearly 9 lbs per day per patient, or 2 cu ft per day per patient. The weight of solid waste per patient was found to be significantly related to the following:

1. Community characteristics: Presence in a standard metropolitan statistical area, and population of the community.
2. Presence of hospital facilities and services: Research laboratory, pathology laboratory, cobalt therapy, radioisotope utilization, radium therapy, hospital controlled school of professional or practical nursing, and psychiatric inpatient unit.
3. Variables describing hospital utilization: Patient census, number of surgical procedures per year, number of outpatient visits per year, and number of live births per year.
4. Hospital bed capacity.
5. Employees and trainees: Number of employees, number of employees residing at the hospital, number of trainees, and number of trainees residing at the hospital.
6. Other hospital characteristics: Possession of a

state license and accreditation by the Joint
Commission on Accreditation of Hospitals.

An equation was developed, including the most highly correlated variables from among those listed, for use in estimating pounds of solid waste per day per patient for specified conditions. This equation, which was one of the most important results of the research, was a much better estimator of contribution of solid waste per day per patient than bed capacity or patient census alone.

Quantity of Solid Waste Per Admission. Means of approximately 70 lbs per admission and 15 cu ft per admission were found.

Composition of Hospital Solid Waste. Combustible rubbish was found to be the largest component of hospital solid waste, comprising approximately 50 percent of the total weight. Garbage and noncombustible rubbish, in that sequence, were also substantial components, with biological material accounting for only a small part of the total weight. Combustible rubbish and noncombustible rubbish were found to have mean densities of approximately 3 and 8 lbs per cu ft, respectively.

Sources of Solid Waste Within the Hospital. The areas of the hospital accounting for the greatest quantities of solid waste were dietary facilities, with a mean of nearly 50 percent of the total, and general nursing stations, with 20 percent. The mean percents of the waste from these two sources were greater for hospitals having fewer than 200 beds than for other hospitals.

Solid Waste Collection Operations. The mean quantity of solid waste collected in one load increased with increasing bed capacity, indicating a possible increase in the efficiency of collection. The peak hour with regard to the collection of solid waste was usually quite pronounced, accounting for a mean of more than one-fourth of the daily total whether determined for combined volume, combined weight, or the combustible rubbish fraction. The peak hour accounted for a much larger portion of the daily total weight and volume of solid waste in hospitals with under 200 beds than in larger hospitals.

Disposition of Hospital Solid Waste. Incineration at the hospital and grinding with discharge to the sewerage system were the two methods of disposal of solid waste accounting for the greatest weights of solid waste, averaging approximately 35 percent and 20 percent of the total, respectively. Other methods of disposal of hospital solid waste, listed here in decreasing order of weight of waste involved, included dumping, sanitary landfill, hog feeding, and municipal incineration.

Public Health Significance of Findings

The findings of the study have important public health implications both in the hospital and in the community outside the institution.

Beginning within the hospital, the poor practice with regard to enclosure of solid waste in bags is important. The frequent failure to enclose the waste or to properly utilize disposable bags, as already described, suggests potential for dissemination of microbiological contamination into the air. The hazard is within the hospital and primarily twofold, including (1) the occupational hazard of persons handling solid waste contracting disease from contaminated aerosols involved, and (2) hazard of disease spread to patients and others in the hospital. The degree of danger from inadequate enclosure of solid waste requires additional evaluation.

The methods used for solid waste collection within the hospital, revealed by this study to involve predominantly pushcarts, have public health significance. The carts used were frequently constructed in such a way that sanitizing was not possible, undoubtedly providing surfaces where microorganisms could multiply and possibly contaminate various areas of the hospital. The routing of refuse carts into and through areas where freedom from contamination is critical and near clean equipment and supplies increased the probability of contamination being spread. It is also important to note that methods of collection within the hospital involve very extensive use of poorly qualified operational personnel. The public health problem is twofold in that such personnel have (1) repeated exposure to chemically and microbiologically contaminated material, as well as exposure to other hazards, and (2) minimal knowledge, skill, or equipment with which to protect either themselves or others in the hospital from hazards.

The public health significance of the frequent use of chutes for solid waste handling at hospitals needs little comment. These facilities virtually were never found to be constructed with proper means of preventing the spread of microbiological contamination, such as mechanical exhausts or interlocking charging doors. The practice of using the same chute for both solid waste and linen suggests potential for the spread of contamination. While the hospitals generally did not cite specific instances of the spread of disease via solid waste chutes, it is likely that contamination was spread at many of the chute installations.

The manner of use of incinerators at the hospitals raised important questions of air pollution and hazard within the hospital. The lack of skilled operation for many hospital incinerators appeared to exacerbate air pollution problems. Further, lack of specifically designated and skilled operators also needlessly exposed many personnel who collected solid waste within the hospital to explosions in the incinerator and other hazards. Personnel who collected solid waste and were required to also charge it to the incinerator generally lacked or failed to use the most simple personal protective equipment, such as face shields. The combination of widespread use of incinerators at hospitals, very pronounced peak hours in the collection of solid waste, and unskilled operation of incinerators usually meant that (1) incinerators were frequently operated at above rated capacity for brief periods, and (2) at most other times, incinerators were operated at below desirable temperatures. leading to a potential for air pollution. Proper incinerator operation was made far more difficult by frequent lack of information as to the rated capacity of the incinerator.

The study revealed that the dietary department typically generated much more solid waste than any other area of the hospital. Although solid waste from this source has public health significance with respect to putrescibility and insect and rodent vectors, it would not usually be contaminated with pathogens. The very large fraction of the waste from hospital dietary departments should therefore be generally acceptable in municipal disposal facilities. Smaller hospitals typically have a larger fraction of waste from dietary departments. Biological material and radioactive solid waste, two of the most hazardous types of hospital solid waste, appeared generally to constitute quite small fractions of the total amount of solid waste generated, with separate handling and treatment usually desirable. Combustible rubbish, the largest component of hospital solid waste, probably is associated with at least small amounts of microbiological and chemical contamination at most hospitals. Nevertheless, the nature of this waste may make it relatively amenable to environmentally satisfactory municipal disposal by such methods as incineration, composting, and sanitary landfill.

Public health problems with the hauling away of solid waste were found to begin at the hospital. The storage receptacles for such waste were, at many hospitals, very poor in appearance, highly soiled, and accessible to insects. The problem of waste storage at hospitals has been affected by the use of stationary compactor systems, in that waste may be hauled away less frequently than in the past.

The type of solid waste hauled from hospitals will frequently involve hazards. Although biological material, chemical waste, disposable needles, and grossly contaminated wastes may be found only occasionally or in small amounts in solid waste hauled from hospitals, materials from many areas of the hospital must be considered as potentially hazardous. The hospital is not the only source of hazardous solid waste in the community, such materials also being generated in physicians' offices, nursing homes and veterinary clinics. Most municipal disposal sites which were seen appeared to offer potential for environmental contamination from even ordinary community solid waste, including one or more of such problems as insect and rodent breeding and harborage, air pollution, and water pollution. The design and operation of a municipal solid waste disposal site should be based on having at least a portion of the material which it receives being contaminated or otherwise hazardous. It is essential that routine operation provide adequate disposal of contaminated materials present in relatively small amounts in community solid waste. Therefore, a disposal site which is satisfactory for ordinary community waste should also be satisfactory for hospital solid waste, particularly if grossly contaminated materials receive separate disposal by the hospital.

The practice of a significant fraction of hospitals permitting food waste to be hauled away by hog farmers probably contributes to an undesirable practice in most instances. The public health problems associated with hog feeding are well-known, and it is incongruous that an institution established for the care of the sick and injured should contribute to disease hazard.

The quantities of solid waste generated at hospitals have public health significance. Since large amounts of solid waste, much of it potentially contaminated, are concentrated at one point, there exists the possibility of a concentration of environmental health problems at hospitals. In fact, this is found at many hospitals, where such problems as occupational injuries, air pollution, insect breeding, and rodent harborage are found associated with solid waste. There is a need to understand the factors which determine the quantities and characteristics of solid waste generated at hospitals. The present virtual environmental crisis in solid waste handling at many hospitals is at least partly due to a rapid increase in the quantity of solid waste, apparently not expected when present facilities were planned. The identification of factors relating to quantity of solid waste in the present study should help provide a basis for designing future hospital construction and alteration with the capability for handling changed quantity and characteristics of hospital solid waste. In this way, future environmental problems related to hospital solid waste handling may be averted. This is particularly appropriate in view of indications, as in the present study, that the quantity of solid waste per patient is increasing, and that the characteristics of hospital solid waste are changing.

Additional Study

This study should be considered as only an introductory investigation of certain aspects of hospital solid waste management.

There is a need for additional study, some of which is described here as particularly appropriate in following the present investigation.

This study identified a number of factors correlated with quantities of solid waste. Additional study might profitably be provided to further develop means for estimating waste quantities, thus, for example, increasing usefulness in the design of new facilities. This might include identification of additional relevant factors and further elucidation of the nature of the relations between the various factors and quantity of hospital solid waste.

The preceding could be used to develop a mathematical model relating quantities and characteristics of hospital solid waste to the various appropriate parameters. Using computer techniques, the model could be used to determine quantities and characteristics of solid waste as a design basis for hospital solid waste management systems in a variety of situations. The model could also be used to estimate the effects of various combinations of possible future conditions on quantities and characteristics of hospital solid waste.

An important need for additional study is the optimization of hospital solid waste systems, including both environmental health and economic factors, for the many different hospital situations. Initial efforts might consider optimization of only portions of relatively simple hospital systems. However a complete optimization would require consideration of the entire hospital solid waste management system, with all its variability, and including effects at the hospital and away from the hospital. A task as complex as this would probably best be approached by mathematical modeling and use of a computer for detailed analysis. The preceding implies an operations research consideration of the problem.

Recommendations

Recommendations derived from the study are as follows:

1. All applicable solid waste generated at hospitals should, at the point of generation, be sealed in disposable bags or otherwise enclosed in such manner as to preclude or minimize contamination of the hospital environment. Exceptions to this might include bulky items of waste which are not contaminated and for which enclosure may not be practical, and wastes which are disposed of immediately at the point of generation, such as food waste placed in grinders and discharged to the sewerage system.
2. Carts and other equipment used in hospital solid waste handling should be constructed in such a manner as to be readily sanitized and maintained in sanitary conditions.

3. Chutes for conveyance of solid waste should be constructed and operated in such a manner as to preclude or minimize microbiological contamination of air, linen, and various areas of the hospital.
4. Measures should be instituted to reduce the danger to those hospital personnel involved in solid waste collection resulting from exposure to microbiological agents, toxic chemical wastes, and safety hazards. Immediate measures should include immunization and use of personal protective equipment such as gloves and protective clothing. Future measures should include introduction of equipment and systems designed to reduce the use of manpower in hospital solid waste handling systems.
5. Higher qualifications should be required of operational personnel involved in hospital solid waste handling. Better qualified personnel should mean that training could be provided regarding the hazards associated with hospital solid waste and the means of protecting themselves, others in the hospital, and the community. The requirement of higher qualifications should be introduced concurrently with the introduction of more efficient and less hazardous systems of solid waste handling, which would attract more capable personnel

and fully utilize their qualifications.

6. Improvement should be made in the operation of incinerators at hospitals. It is important that operation be exclusively by experienced, skilled, and knowledgeable personnel. It is of particular importance that solid waste be charged to incinerators at a rate which does not exceed capacity, but which is high enough to maintain a satisfactory combustion temperature. This may require coordination of solid waste collection with the daily period of incinerator operation, and could also necessitate the provision of solid waste storage in protected areas near incinerators to allow the leveling of peak loads in charging incinerators.

7. Materials such as human tissue, other biological waste, and additional varieties of particularly hazardous materials should not be included as part of the solid waste hauled away from the hospital for disposal. The handling and disposal of this waste should be such that it precludes or minimizes hazard to health. Incineration at the hospital should be appropriate for many types of hazardous solid waste, provided that design, installation,

and operation of the facility is adequate.

8. Municipal facilities which are adequate to handle and dispose of general community solid waste should usually accept hospital solid waste, provided that adequate capacity is available in the community facility, and that particularly hazardous wastes, as described in the preceding, are excluded. Such hospital solid waste should generally cause no more pollution or hazard than other waste at a municipal facility.

9. Hospitals should not, in general, provide food waste for hog feeding.

10. Hospital solid waste management systems should be designed on the basis of quantities and characteristics of solid waste expected at present and in the future. Since there are indications that quantities of hospital solid waste are increasing and characteristics are changing, hospital solid waste management systems should be designed with the flexibility to accommodate substantial changes, or the ability to be readily expanded or appropriately altered.

Closing

This study has considered various aspects of the handling of hospital solid waste from the areas of generation to the sites of ultimate disposal. A number of factors related to the quantity of solid waste per patient were identified, and certain of the most important factors were included in an equation. This and other results of the study should have value to many persons interested in solid waste handling at hospitals.

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APPENDIX

RESEARCH FORMS

Form HSW-1
8/68

Background Information on Hospital

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification and Communication Data	Data No.	Column	Code
1. Name of hospital ________________			
2. Hospital identification number	1	1-3	_ _ _
3. Survey date: Month	2	4-5	_ _
Day	3	6-7	_ _
Year	4	8-9	_ _
4. Hospital mailing address: Street ________________ City ________________ State __________ Zip code ______			
5. Hospital telephone: Area code ______ No. __________			
6. Hospital personnel: Administrator ____________ Asst. or assoc. administrator ____________ Maintenance ____________ Housekeeping ____________ Food service ____________ Pathology ____________ Obstetrics ____________ Radiology ____________ Pharmacy ____________ Laboratories ____________ Nursing ____________ Personnel ____________ Surgery ____________ Other ____________			

Section B. General Information	Data No.	Column	Code
7. Training at University of Minnesota: 0 - None 1 - President, director, administrator, etc. 2 - Assistant or associate administrator 4 - Engineer 8 - Other. Specify ________________ (Do not include administrative residents)	5	10-11	_ _
8. Year that original construction of hospital was completed at present site: 0 - Not completed 5 - 1930-1939 1 - Before 1900 6 - 1940-1949 2 - 1900-1909 7 - 1950-1959 3 - 1910-1919 8 - 1960-Present 4 - 1920-1929 9 - Unknown	6	12	_
9. Year that last expansion of bed capacity or other major alteration was completed: 0 - No major alterations 1 - Before 1950 2 - 1950-1954 3 - 1955-1959 4 - 1960-1964 5 - 1965-Present 6 - Under construction during survey. Expected date of completion ____________	7	13	_

	Data No.	Column	Code
10. Describe last major alteration of this hospital: 00 - No major alterations 01 - Expansion of bed capacity, No. of beds added in expansion ______ 02 - Addition or expansion of ancillary facilities. Describe ______ 04 - Remodeling ______ 08 - Facilities for solid waste handling and/or disposal. Describe ______ 16 - Other. Describe ______	8	14-15	_ _
11. Award of grants under the Hill-Burton program: 0 - No grants 1 - Original construction 2 - One or more completed alterations 4 - Alterations under construction 9 - Not determined	9	16	_
12. Control of hospital: 1 - Non-governmental, non-profit 2 - Other. Specify ______	10	17	_
13. Type of service: 1 - General 2 - Other. Specify ______	11	18	_
14. Hospital approvals: 0 - Neither 1 - Current state license 2 - Joint Commission on Accreditation of Hospitals	12	19	_

Section C. Activities and Facilities at Hospital	Data No.	Column	Code
15. Hospital teaching activities: 00 - None of listed 01 - Residency (medical) 02 - Internship 04 - Medical school affiliation 08 - Hospital controlled professional and/or practical nursing study. Describe ______ 16 - Hospital controlled study for technicians. Specify type ______ 32 - Hospital provides clinical experience for students in program controlled by college, vocational school, etc. Describe ______ Describe any other teaching activities ______	13	20-21	_ _
16. Hospital facilities and services: 00 - None of listed 01 - Pathology laboratory 02 - Pharmacy 04 - Radioisotope therapy 08 - Cobalt therapy 16 - Radium therapy 32 - Clinical laboratory	14	22-23	_ _

	Data No.	Column	Code
17. Research activity (not administrative research): 0 - None 1 - Laboratory research not normally involving animals. Describe ____ 2 - Animal research Indicate number and kinds of animals ____ 4 - Other. Describe ____	15	24	_
Latest available data for expected or actual research expenditures (thousands of dollars)	16	25-28	_ _ _ _
18. Laundry: 1 - Done at hospital 2 - Laundry service purchased off-site 3 - Other. Describe ____	17	29	_
19. Describe food preparation facilities: 0 - None 1 - Main kitchens 2 - Floor kitchens. Indicate number and describe function ____ If only partial food preparation facilities are at the hospital, describe ____	18	30	_
20. Warehouse facilities (i.e., commodity storage): 0 - None 1 - Shared with other hospitals. Location ____ 2 - Individual facilities on-site 3 - Other. Describe ____	19	31	_
21. No. of operating rooms (Include facilities for both major and minor surgical procedures.)	20	32-33	_ _
22. Number of surgical procedures per year (Indicate hundreds, use latest data.)	21	34-36	_ _ _
23. Number of outpatient visits per year (Indicate thousands, use latest data.)	22	37-39	_ _ _
24. Number of live births per year (Indicate hundreds, use latest data.)	23	40-42	_ _ _
25. Units at hospital for certain specialized care (Indicate average patient stay for each, if available, and bed capacity at time of survey.): 0 - None 1 - Psychiatric inpatient unit Stay ____ Beds ____ 2 - Rehabilitation inpatient unit Stay ____ Beds ____ 4 - Other. Describe ____ Stay ____ Beds ____ Specify any unit in which over 50% of admissions have a stay of 30 days or longer: ____	24	43	_

Section D. Capacity and Use of Hospital	Data No.	Column	Code
26. Hospital capacity at time of survey:			
a. Newborn bassinets	25	44-46	_ _ _
b. Bed capacity for adult and pediatric cases (i.e., all except newborn)	26	47-50	_ _ _ _
27. Average daily patient census (Use latest figures for complete year, unless a change in hospital capacity, etc. makes this misleading):			
a. Average daily newborn census	27	51-53	_ _ _
b. Average daily census for adult and pediatric cases (i.e., all except newborn)	28	54-57	_ _ _ _
28. Total staff (full-time equivalents, including all personnel on hospital payroll, and including donated services of members of religious orders, but excluding trainees, private duty nurses, and volunteers) at time of survey. (Record as tens.)	29	58-60	_ _ _
Number of staff members residing in hospital complex at time of survey	30	61-63	_ _ _
29. Total number of trainees at time of survey. If significantly different from usual, describe and explain ______________________	31	64-66	_ _ _
Total number of trainees residing in hospital complex at time of survey	32	67-69	_ _ _
30. Visiting policy (Indicate data which pertain to the majority of patients):			
a. Number of hours per day when visiting is permitted	33	70-71	_ _
b. Maximum number of visitors permitted to see a patient at one time: 0 - No limit 1 - Limit of two 2 - Other. Describe ______________	34	72	_
Comment on strictness of enforcement, applicability of noted hours, etc. ______________			
31. Card designator	35	80	1

Form HSW-2
8/68

On-site Solid Waste Treatment and Disposal

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification	Data No.	Column	Code
1. Name of hospital ____________________			
2. Hospital identification number	1	1-3	___
3. Survey date: Month	2	4-5	__
Day	3	6-7	__
Year	4	8-9	__

Section B. Waste Containment, Transport, and Storage at Hospital.	Data No.	Column	Code
4. Containment of solid waste: a. Describe containment method used for largest weight of waste: 0 - No containment (i.e., loose) 1 - Plastic bags 2 - Paper bags 3 - Other. Describe ____________ Waste types for which major method listed above is used ____________	5	10	_
b. Describe any other containment methods which are used for wastes: 00 - No other containment method 01 - Plastic bags 02 - Paper bags 04 - Wrapping 08 - Other. Describe ____________ Waste types involved ____________ What waste is left "unenclosed"? ____________	6	11-12	__
5. Means used for transport of greatest weight of waste within hospital, excluding any chutes: 01 - Pulping 02 - Rigid walled carts 03 - Carts with removable fabric containers 04 - Waste receptacles carried on tubular-frame carts 05 - Waste receptacles carried on flat carts 06 - Waste on tubular frame carts, without receptacles 07 - Waste on flat carts, without receptacles 08 - Hand carry 09 - Other. Describe ____________ 10 - Not applicable. Explain ____________ Describe other methods of transport within the hospital and indicate types of waste involved ____________	7	13-14	__
6. If walled carts, containers on flat carts, or other equipment with volumes that are defined are used to transfer most waste in the hospital, indicate volume (cu.ft.). Enter zeros if not applicable.	8	15-16	__

Form HSW-2, Page 2

	Data No.	Column	Code
7. Solid Waste Chutes. a. Number at hospital	9	17-18	_ _
b. Number in use If any chutes have been abandoned, indicate the reason ____	10	19-20	_ _
c. Number of times (average) each chute is cleaned per year. (Indicate zeros if less than one, or if not applicable). Describe equipment and method used ____	11	21-22	_ _
d. Indicate problems resulting from use of chutes. (In each instance, describe cause and indicate corrective action which has been taken.) 00 - No problems noted 01 - Blocking. Describe ____ 02 - Fire. Describe ____ 04 - Odors. Describe ____ C3 - Source of contamination spread in specific instances. Describe ____ 16 - Other. Describe ____ 99 - Not applicable	12	23-24	_ _
e. Is chute provided with a sprinkler system for fire protection? 0 - No 1 - Yes 9 - Not applicable.	13	25	_
If several chutes, code for unit receiving most weight of solid waste, or newer unit, and list data for other units here ____ ____			
8. Number of central storage locations for waste collected within hospital. (Do not include utility rooms at nursing stations, facilities for handling small amounts of special wastes, etc.) Describe ____ ____	14	26-27	_ _
9. Storage of solid waste for removal by hauler of largest weight of waste (not specialized storage for garbage): a. Containers for the solid waste: 00 - No containers 01 - G.I. cans. Indicate number and volume ____ 02 - Barrels, drums, etc. Indicate number and volume ____ 04 - Specialized non-compacting bulk solid waste containers, designed to be mechanically emptied into truck or hauled away. Indicate number and volume ____ 08 - Stationary compactor receiver receptacles. Indicate number and volume ____ ____ 16 - Other. Describe and indicate number and volume ____ 99 - Not applicable	15	28-29	_ _
Describe containers for other than major hauler, and indicate number and volume ____			

	Data No.	Column	Code
b. If containers are used, indicate if: 01 - Containers are impervious. Describe ________ 02 - Containers have tight-fitting covers. Describe ________ 04 - Covers kept on containers 08 - Containers clean 16 - Containers in satisfactory state of repair 32 - Other. Describe ________ 99 - Not applicable Give data for containers other than those pertaining to the major hauler ________	16	30-31	_ _
c. Shelter for refuse containers or stored refuse, major hauler: 00 - None (i.e., outside) 01 - Specialized shelter or outbuilding. Describe ________ 02 - Room in building. Describe ________ 04 - On hauling vehicle. Describe ________ 08 - Other. Describe ________ 99. Not applicable Give data for shelter for solid waste storage other than pertaining to major hauler ________	17	32-33	_ _
10. Capacity of central storage (tens of cu. ft.), as calculated from data in 9a. a. Capacity for storing solid waste for major hauler	18	34-37	_ _ _ _
b. Capacity for central storage of solid waste for hauling, other than by major hauler	19	38-41	_ _ _ _
c. Capacity of other central storage (for example, at incinerator room, but excluding utility rooms, etc.)	20	42-45	_ _ _ _
11. Discuss how readily the central storage at the hospital could be expanded ________			
12. Problems at hospital resulting from hauling away of solid wastes: 00 - No problems noted 01 - Odor from storage. Describe ________ 02 - Insects and/or rodents. Describe ________ 04 - Noise problem during waste removal. Describe ________ 08 - Spilling during waste removal. Describe ________ 16 - Unauthorized persons have access to stored waste. Describe ________ 32 - Other. Describe ________ 99 - Not applicable (Under "describe" indicate cause, corrective action, frequency, etc.)	21	46-47	_ _
Section C. Radioactive Solid Wastes	Data No.		Code
13. Use of radioactive materials in unsealed sources: 0 - None 1 - Diagnosis 2 - Therapy 4 - Other. Describe ________	22	48	_

	Data No.	Column	Code
14. Isotopes used ____________			
15. Estimate total amount of isotope material used in average month (millicuries). Enter zeros if not known or not applicable	23	49-52	_ _ _ _
16. Describe nature of solid waste contaminated with radioisotopes. (Exclude excreta which are flushed down drain immediately upon generation): 01 - Combustible material. Describe ____________ 02 - Non-combustible. Describe ____________ 04 - Dead experimental animals. Indicate number and variety ____________ 08 - Other. Describe ____________ 99 - Not applicable ____________	24	53-54	_ _
17. Indicate disposal of radioactive solid wastes. (Exclude excreta, as described in item 16): 01 - Incinerated at hospital, without storage to reduce radioactivity. Describe ____________ 02 - Hauling away with bulk of wastes without storage to reduce radioactivity. Discuss, and describe ____________ 04 - Specialized hauling of radioactive wastes. Describe ____________ 08 - Storage to reduce radioactivity 16 - Other. Describe ____________ 99 - Not applicable	25	55-56	_ _
18. If storage is provided for radioactive solid wastes to reduce activity, indicate the following: a. How is it determined that length of storage has been adequate? 0 - No data 1 - Estimation 2 - Monitoring. Describe instrument ____________ 4 - Knowledge of isotopes present and half-lives 8 - Other. Describe ____________ 99 - Not applicable	26	57-58	_ _
b. Describe storage: 00 - None of listed items 01 - Inside building. If outside, explain ____________ 02 - Kept in specialized radioactive waste storage room. Describe ____________ 04 - Waste kept under lock or otherwise accessible only to authorized persons. Describe ____________ 08 - Containers with covers used for waste. Describe ____________ Do containers bear proper radiation warning markings? ____________ 16 - Waste enclosed so as to minimize dispersion into air (e.g., plastic bag). Describe ____________ 99 - Not applicable	27	59-60	_ _
c. Final disposal of waste, after storage: 1 - Disposal in same manner as other waste of same character. Describe ____________ 2 - Other. Describe ____________ 9 - Not applicable	28	61	_

	Data No.	Column	Code

19. Person assigned to handle radioactive solid wastes:
0 - No defined assignment
1 - Radiologist
2 - Other professional person. Indicate ____________
____
3 - Technician
4 - Other. Describe ______________________________
9 - Not applicable 29 62 _

20. Estimate total quantity of radioactive solid waste generated:
________________lb./day
________________cu. ft./day
Indicate basis for estimate:______________________

Section D. Miscellaneous Solid Wastes	Data No.	Column	Code

21. Indicate the disposal method which is used for the greatest weight of each of the wastes noted:
a. Casts:
1 - Hauled away. Describe ______________________
2 - Incinerated on-site
3 - Other. Describe ____________________________
9 - Not applicable 30 63 _
Describe any disposal, other than major method __
____
b. Medications:
1 - To drain. Describe how this is done for solids ________________________________
2 - Incinerated on-site
3 - Hauled away
4 - Other. Describe ____________________________
9 - Not applicable 31 64 _
Describe any precautions taken before disposal, special handling, etc. ____________________________
____
Describe any disposal, other than major method __
____
Discuss the return of unused medications to suppliers: ______________________________________
c. Disposable needles and syringes:
1 - Incineration on-site
2 - Hauling away. Describe final disposal, etc.
____
3 - Other. Describe ____________________________
9 - Not applicable 32 65 _
List data for any other disposal methods used ______
____

22. Describe processing before disposal (needles/syringes):
00 - None noted
01 - Sealed in container
02 - Broken by hand
04 - Crushed
08 - Disinfected or sterilized. Describe __________
____
16 - Other. Describe ____________________________
99 - Not applicable 33 66-67 _ _

23. Card designator 34 80 2

Form HSW-3
8/68

On-site Solid Waste Treatment and Disposal - Continuation

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification	Data No.	Column	Code
1. Name of hospital ______________________			
2. Hospital identification number	1	1-3	_ _ _
3. Survey date: Month	2	4-5	_ _
Day	3	6-7	_ _
Year	4	8-9	_ _

Section B. Incineration On-site	Data No.	Column	Code
4. Number of operational incinerators	5	10	_
5. Number of operational incinerators in use: (Indicate zero, if none or not applicable.) If an existing operational incinerator is not used, explain ______________________	6	11	_
6. Year of installation of incinerator in use: 0 - Not known 1 - before 1945 2 - 1945-1949 3 - 1950-1954 4 - 1955-1959 5 - 1960-1964 6 - 1965-Present 9 - Not applicable (If an incinerator does not exist, or is not used, code not applicable. If several incinerators are present, code data for the unit receiving the most weight of waste, or, if both receive the same amount, code data for newer unit, and note data for other units here ______________________	7	12	_
7. Have any major alterations been made on incinerator (unit described in item 6)? 0 - No 1 - Yes. Describe ______________________ 9 - Not applicable Data for other units in use ______________________	8	13	_
8. Availability of auxiliary fuel for incinerator (unit described in item 6): 0 - None 1 - Natural gas 2 - Other. Specify ______________________ 9 - Not applicable Burner capacity: ____________BTU/hr. Data for other units in use ______________________	9	14	_
9. Use of auxiliary fuel (unit described in item 6): 00 - Not presently used 01 - Used to ignite wastes 02 - Used for specific wastes, rather than all. Describe ______________________ 04 - Generally burning during entire time incinerator used 08 - Other. Describe ______________________ 99 - Not applicable	10	15-16	_ _

	Data No.	Column	Code
10. Availability of forced draft on incinerator (unit described in item 6): 0 - Not available 1 - Available 9 - Not applicable Data for other units in use ________________	11	17	_
11. Use of forced draft (incinerator described in item 6): 0 - Not presently used 1 - Used at same times as auxiliary fuel. How accomplished ________________ 2 - Used, but not necessarily at same times as auxiliary fuel. Describe ____________ ________________ 9 - Not applicable	12	18	_
12. Incinerator capacity: a. Total capacity of all incinerators in use	13	19-21	_ _ _
b. Capacity of incinerator considered in coding (unit described in item 6.) (Indicate tens of lb/hour. Enter zeros if not applicable.)	14	22-24	_ _ _
13. Times of incinerator operation (i.e., during which solid waste is or may be deposited in the incinerator for prompt ignition) for unit described in item 6: a. Days per week (average)	15	25	_
b. Hours per day (average) (Enter zeros if not applicable) Data for other units in use ________________	16	26-27	_ _
14. Solid wastes sent to that incinerator which receives most weight of solid waste (unit described in item 6): 01 - Combustible rubbish 02 - Garbage 04 - Biological materials 08 - Non-combustible rubbish 16 - Radioactive wastes (not given adequate time for decay) 32 - Other. Specify ________________ 99 - Not applicable	17	28-29	_ _
15. Solid waste sent to any other on-site incinerator(s): 01 - Combustible rubbish 02 - Garbage 04 - Biological materials 08 - Non-combustible rubbish 16 - Radioactive wastes (not given adequate time for decay) 32 - Other. Specify ________________ 99 - Not applicable	18	30-31	_ _
16. Incinerator location (unit described in item 6): 1 - Outdoors. Describe any shelter provided ________ ________________ 2 - Indoors, in separate incinerator room 3 - Indoors, in room shared with other facility. Describe ________________ 4 - Other. Describe ________________ 9 - Not applicable Data for other units in use ________________ ________________	19	32	_

	Data No.	Column	Code
17. Types of incinerator (unit described in item 6): 1 - Flue-fed 2 - Other. Describe, if appropriate ____ 9 - Not applicable Data for other units in use ____	20	33	_
18. Incinerator features (unit described in item 6): 00 - None of listed 01 - Air pollution control device. Describe type, operation, etc. ____ 02 - Two chamber design 04 - Separate stack. If stack not separate, indicate what facility shared with ____ 08 - Waste heat from incinerator utilized. Describe ____ 16 - Other. Describe ____ 99 - Not applicable Data for other units in use ____	21	34-35	_ _
19. Combustible materials in area of incinerator (unit described in item 6): 0 - None present 1 - Present. Describe ____ 9 - Not applicable Data for other units in use ____	22	36	_
20. If incinerator is located indoors, describe fire safety arrangements (unit described in item 6): 0 - None listed 1 - Construction designed to satisfactorily retard spread of fires (i.e., incinerator located in room with fire resistant walls, door, ceiling, etc.) 2 - Sprinkler system 4 - Other. Describe ____ 9 - Not applicable Data for other units in use ____	23	37	_
21. Average number of times ashes removed each week (unit described in item 6): 0 - <1 1 - 1-2 2 - 3-4 3 - 5-6 4 - 7 5 - 8-14 6 - 15-21 7 - ≥22 9 - Not applicable Specify ____ Data for other units in use ____	24	38	_
22. Reduction in weight during incineration for unit described in item 6. (Code nearest percent, and indicate zeros if not determined or not applicable.) Data for other units in use ____	25	39-40	_ _
23. Disposal of incinerator residue: 1 - Hauling away. Final disposal ____ 2 - Other. Describe ____ 9 - Not applicable	26	41	_

	Data No.	Column	Code
24. Incinerator operator (for unit described in item 6): 0 - None 1 - Operator(s) provided (e.g., not an instance where persons unskilled in incinerator operation charge waste) 2 - Other. Describe ________ 9 - Not applicable Data for other units in use ________	27	42	_
25. Safety equipment for incinerator operators (e.g., masks, safety glasses, gloves, etc.) for unit described in item 6): 0 - None provided 1 - Provided. Describe ________ 2 - Used 9 - Not applicable Data for other units in use ________	28	43	_
26. Complaints about incinerator emission (unit described in item 6): 00 - None 01 - On hospital premises. Describe problem ________ 02 - Private sources outside hospital. Describe problem ________ 04 - Air pollution control agency for air pollution outside hospital. Describe problem ________ 08 - Other. Indicate, and describe problem ________ 99 - Not applicable Describe any corrective action ________ Data for other units in use ________	29	44-45	_ _
27. Observation of incinerator emission immediately after charging refuse (unit described in item 6): 0 - Not determined 1 - No black color noted 2 - Slight smoke density (Ringlemann 2 or less) 3 - Medium smoke density (Ringlemann 3) 4 - High smoke density (Ringlemann 4 or higher) 9 - Not applicable Data for other units in use ________	30	46	_
28. Other problems with incineration (unit described in item 6): 00 - None listed 01 - Explosion in incinerator 02 - Personnel injury. Describe ________ 04 - Emission of smoke into hospital 08 - Fouling of grates 16 - Excessive maintenance, other than fouling of grates. Describe ________ 32 - Other. Describe ________ 99 - Not applicable Describe any corrective action ________ Data for other units in use ________	31	47-48	_ _
29. Condition of incinerator residue (unit described in item 6): 0 - Not determined 1 - Very little unburned combustible matter 2 - Considerable unburned combustible matter. Describe ________ 9 - Not applicable Data for other units in use ________	32	49	_

	Data No.	Column	Code
30. Indicate any of the following treatment or disposal methods which are available at the hospital: 00 - None 01 - Baling. Describe ____ 02 - Crushing. Describe ____ 04 - Land disposal on immediate hospital premises. Describe ____ 08 - Other, not considered elsewhere. Describe ____	33	50-51	_ _
Section C. Grinding On-site with Discharge to Sewerage System - General	Data No.	Column	Code
31. Materials disposed of through grinders (not including potato peeling devices, pulping devices, etc.): 0 - None 1 - Food waste 2 - Afterbirth material 4 - Other biological material. Describe ____ 8 - Other (exclude incidental amounts of wastes, such as small quantities of paper from dishwashing, etc.) Describe ____	34	52	_
32. Number of disposers: a. For food wastes b. For other wastes	 35 36	 53-54 55	 _ _ _
33. Disposal of waste sent through grinders: 1 - Public sewer system. Is system served by a sewage treatment plant? ____ 2 - On-site disposal. Describe ____ 9 - Not applicable	37	56	_
34. Horsepower of grinders (list horsepower for all units, and code means): a. Food waste grinders: Horsepower ____ Mean ____	38	57-59	_ . _
b. Grinders for other wastes: Horsepower ____ Mean ____ (If no disposers indicate zeros)	39	60-62	_ . _
Section D. Food Preparation Wastes	Data No.	Column	Code
35. Location of food waste disposers: 01 - Nursing station kitchens. Describe functions, number, etc. ____ 02 - Food preparation area(s) in main kitchen. Describe ____ 04 - Dishwashing area. Describe ____ 08 - Potwashing area. Describe ____ 16 - Other. Describe ____ 99 - Not applicable	40	63-64	_ _
36. Mean time that food waste grinders are in operation: 0 - Less than 1 hr./day 1 - 1 2 - 2-3 3 - 4-5 4 - 6-10 5 - More than 10 6 - Not determined 9 - Not applicable	41	65	_

	Data No.	Column	Code
37. Problems with waste disposal by food grinders: 00 - None of noted items 01 - Blocking of lines. Indicate frequency and describe cause and any corrective action taken ____ 02 - Excess maintenance, other than due to blocking of lines. Describe ____ 04 - Proximity to clean area. Describe clean area and list distance ____ 08 - Other (e.g., injury, noise, odor, etc.). Describe ____ 99 - Not applicable List data for grinders for other than food waste ____	42	66-67	_ _
38. Storage near point of generation, handling, etc. of kitchen wastes: 00 - None of noted items 01 - Refrigerated storage. Describe ____ 02 - Garbage used for hog feeding. Describe ____ 04 - Other kitchen wastes salvaged. Describe ____ 08 - Other. Describe ____ 99 - Not applicable	43	68-69	_ _

Section E. Biological Materials	Data No.	Column	Code
39. Storage near point of generation, handling, etc. of laboratory wastes: 00 - None of noted items 01 - Disinfection and/or sterilization. Indicate method and wastes involved ____ 02 - Enclosed in bags. Describe ____ 04 - Covered containers for hazardous wastes. Describe ____ 08 - Refrigeration. Describe ____ 16 - Special transfer in hospital to disposal points. Describe and indicate disposal ____ 32 - Other. Describe ____ 99 - Not applicable	44	70-71	_ _
Instructions for items 40-45: Code the method of disposal used for most of the weight of material in each category noted, use narrative to describe any other method used, and indicate any difference in variety for the wastes sent to each method of disposal.			
40. Major disposition of afterbirth material: 1 - Use by drug firm. Describe ____ Refrigerated? ____ 2 - Incineration on-site. Describe ____ 3 - Grinding on-site. Describe ____ 4 - Hauling away. Indicate whether hauled separately, location of final disposal, method of final disposal, frequency of removal, etc. ____ 5 - Other. Describe ____ 9 - Not applicable List data for any other disposal method used ____ Describe storage ____	45	72	_

	Data No.	Column	Code
41. Major disposition of amputated material: 1 - Burial. Describe conditions, location, outside agencies involved, etc. ____ 2 - Incineration on-site. Describe ____ 3 - Grinding on-site. Describe ____ 4 - Hauling away. Indicate whether hauled separately, location of final disposal, method of final disposal, frequency of removal, etc. ____ 5 - Other. Describe ____ 9 - Not applicable List data for any other disposal method used ____ Describe disposal of other contaminated solid wastes from surgery ____ Describe storage ____	46	73	_
42. Major disposition of tissue removed in autopsy: - Replaced in body. If not true for all such tissue, describe distinction, legal requirements, etc. ____ 2 - Incineration on-site. Describe ____ 3 - Grinding on-site. Describe ____ 4 - Hauling away. Indicate whether hauled separately, frequency of final disposal, location of final disposal, method of final disposal, etc. ____ 5 - Other. Describe ____ 9 - Not applicable List data for any other disposal method used ____ Describe storage ____	47	74	_
43. Major disposition of preserved specimens: 1 - Incineration on-site. Describe ____ 2 - Grinding on-site. Describe ____ 3 - Hauling away. Indicate whether hauled separately, location of final disposal, frequency of removal, method of final disposal, etc. ____ 4 - Other. Describe ____ 9 - Not applicable List data for any other disposal methods used ____ Describe storage ____	48	75	_
44. Major disposal of any animal carcasses: 1 - Incineration on-site. Describe ____ 2 - Hauling away. Indicate whether hauled separately, location of final disposal, frequency of removal, method of final disposal, etc. ____ 3 - Other. Describe ____ 9 - Not applicable List data for any other disposal methods used ____ Describe storage ____	49	76	_

	Data No.	Column	Code
45. Major disposal of microbiological cultures: 1 - Washed down drain. Describe ________ ________ 2 - Incinerated on-site. Describe ________ ________ 3 - Hauling away. Describe ________ 9 - Not applicable List data for any other disposal method used ________ ________ Describe storage ________	50	77	___
46. Mean time that grinders for other than food wastes are in operation: 0 - Less than 1 hr./month 1 - 1-10 2 - 11-20 3 - 21-30 4 - 31-50 5 - More than 50 6 - Not determined 9 - Not applicable	51	78	___
47. Describe contamination control measures for grinders which receive biological material: 0 - None noted 1 - Hood. Describe ________ 2 - Exhaust. Describe ________ 4 - Other. Describe ________ 9 - Not applicable If there are several grinders for biological material, code data for unit receiving the most weight of material, and list data for other units here ________ ________	52	79	___
48. Card designator	53	80	3

Form HSW-4
8/68

Municipality Study

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification	Data No.	Column	Code
1. Name of hospital ______________________			
2. Hospital identification number	1	1-3	_ _ _
3. Survey date: Month	2	4-5	_ _
Day	3	6-7	_ _
Year	4	8-9	_ _

Section B. General Characteristics of Community	Data No.	Column	Code
4. Name of community ______________________ County ______________________ State ______________________			
5. Year incorporated as a municipality. Indicate zeros if unincorporated.	5	10-13	_ _ _ _
6. Is community part of a standard metropolitan statistical area? 0 - No 1 - Yes. Specify ______________________	6	14	_
7. 1960 population of community. (Census, thousands. Indicate zeros if not available.)	7	15-18	_ _ _ _
8. Change in population between 1950 and 1960. (Census, nearest percent. Indicate zeros if not available.)	8	19-21	_ _ _
9. Nature of population change indicated in item 7: 0 - Not available 1 - Increase 2 - Decrease 3 - No change	9	22	_
10. Latest population estimate for community. (Thousands, indicate zeros if not available.)	10	23-26	_ _ _ _
Year to which population estimate applies (last two digits)	11	27-28	_ _
Source of estimate ______________________			
11. No. of hospitals listed by American Hospital Association for municipality	12	29-31	_ _ _

Section C. Hauling Waste from the Hospital	Data No.	Column	Code
12. Hauling of solid waste from hospital is done by: 01 - Private hauler(s) retained by hospital. Is hauler who removes most weight of solid waste licensed by municipality? ______________ 02 - Municipal forces 04 - Municipal contract 08 - Hospital vehicle(s) and staff. Why? __________ 16 - Other. Describe ______________________ 99 - Not applicable	13	32-33	_ _

Form HSW-4, Page 2

	Data No.	Column	Code
13. Number of haulers serving hospital (including all those noted in item 12)	14	34	_
14. Indicate name, address, and telephone number of each municipal or private hauler in space provided: Municipal ______ Private ______			
15. Types of solid waste taken from hospital by hauler who removes most weight of solid waste: 01 - Non-combustible rubbish 02 - Combustible rubbish 04 - Garbage 08 - Radioactive waste (not given adequate time for decay) 16 - Biological material 32 - Other. Specify ______ 99 - Not applicable	15	35-36	_ _
16. Types of solid waste removed from hospital by haulers other than one described in item 15: 01 - Non-combustible rubbish 02 - Combustible rubbish 04 - Garbage 08 - Radioactive waste (not given adequate time for decay) 16 - Biological material 32 - Other. Specify ______ 99 - Not applicable	16	37-38	_ _
17. Is solid waste from the hospital salvaged by arrangements with hospital? 0 - No 1 - Yes, afterbirth 2 - Yes, other. Describe ______	17	39	_
18. Frequency of collection of waste, as number of removals per week, for hauler who removes the most weight of waste from hospital: List number of collections per week for any other haulers here ______	18	40-41	_ _
19. If the largest weight of solid waste is removed by the municipality, under municipal contract, or by a private hauler, indicate cost data: a. Basis for determining charge: 0 - Fixed charge, regardless of weight or volume 1 - Fixed charge for each collection 2 - Based on volume removed 3 - Based on weight removed 4 - Other. Describe ______ 9 - Not applicable (no hauling, no charge, etc.)	19	42	_
b. Total charge, as tens of dollars per month. (Indicate zeros if no charge or not applicable)	20	43-45	_ _ _
c. Cost per ton, to nearest dollar. (Indicate zeros if no charge or not applicable. Base weight on total, including any incinerator residue hauled away.)	21	46-47	_ _

	Data No.	Column	Code
20. Would solid wastes hauled into the community be identifiable as originating from a hospital? 0 - No 1 - Yes. Describe how ______ 9 - Not applicable	22	48	_
21. Collection vehicle most often used by hauler who removes the most weight of waste: 1 - Compactor vehicle 2 - Vehicle (non-compactor) with open top. Describe vehicle and any covering used ______ 3 - Non-compactor vehicle manufactured as covered 4 - Vehicle designed to lift on-site container (not GI cans) and transport to disposal site 5 - Other. Describe ______ 9 - Not applicable List data for any other haulers ______	23	49	_

Section D. Community Solid Waste System	Data No.	Column	Code
22. Types of collection of solid waste in community: 0 - None 1 - Municipal 2 - Municipal contract 4 - Private	24	50	_
23. Types of central disposal of solid waste collected from community: 1 - Municipal 2 - Municipal contract 4 - Private 9 - Not applicable	25	51	_
24. Disposal method which receives the most waste from the municipality: 00 - No information 01 - Incinerator 02 - Sanitary landfill 03 - Dump 04 - Other. Specify ______ List any other disposal methods used for community refuse disposal ______	26	52	_
25. Source of any regulation of private haulers: 0 - None 1 - Public works agency 2 - Public health agency 3 - Other. Specify ______ 9 - No private haulers	27	53	_
26. Regulations required of private haulers: 0 - None of listed items 1 - Collection vehicle: type, maintenance, equipment, etc. 2 - Disposal practices 4 - Container: type, cleaning, maintenance, etc. 8 - Licensing required 16 - No private haulers	28	54-55	_ _

	Data No.	Column	Code
27. No. of collections of household solid waste per week: 0 - No collection 1 - One 2 - Two 3 - Three 4 - Other (e.g., more frequent, not on weekly basis, variable frequency, etc.) Describe ____________	29	56	_
28. If waste collection for the community is provided by municipal forces or municipal contract, indicate policy on collecting hospital wastes: 0 - No policy 1 - Acceptable for collection without restriction 2 - Acceptable for collection with restriction. Describe ____________ 3 - Not acceptable for collection 9 - Not applicable	30	57	_
29. If waste disposal for the community is provided by the municipality or under municipal contract, indicate policy on disposing of hospital wastes: 0 - No policy 1 - Acceptable for disposal without restriction 2 - Acceptable for disposal with restriction. Describe ____________ 3 - Not acceptable for disposal 9 - Not applicable	31	58	_
30. Name of disposal site receiving most of waste hauled from hospital ____________ a. Method used to dispose of most of waste hauled from hospital: 1 - Incineration 2 - Sanitary landfill 3 - Dump 4 - Other. Specify ____________ 9 - Not applicable	32	59	_
List any other disposal methods used for hospital's waste ____________ b. Type disposal site receiving most of waste hauled from hospital: 1 - Municipal 2 - Municipal contract 3 - Private 9 - Not applicable	33	60	_
List data for any other disposal sites used for hospital's waste ____________			
31. Additional years of use expected from disposal site which receives most of the weight of solid waste hauled from hospital: 1 - 1 year or less 2 - More than 1 year to 5 years 3 - More than 5 years to 10 years 4 - More than 10 years to 20 years 5 - More than 20 years 6 - No estimate available 9 - Not applicable	34	61	_
List data for any other site receiving waste from the hospital ____________			

	Data No.	Column	Code
32. Conditions at disposal site where most of the weight of waste hauled from the hospital is taken: a. General character of site: 1 - Level area, not marsh or likely to become marshy 2 - Hilly area 3 - Marsh area or likely to become marshy when rainfall occurs 4 - Quarry, sand and gravel excavation, etc. 5 - Other. Describe ____________ 9 - Not applicable	35	62	_
b. Major land use surrounding disposal site (within 0.5 mile): 0 - None 1 - Residential 2 - Commercial 3 - Industrial 4 - Agricultural 5 - Other. Describe ____________ 9 - Not applicable	36	63	_
c. If land disposal site, indicate frequency of covering: 0 - No covering. Describe ____________ 1 - Daily covering of waste ____________ 2 - Covering, but not daily. Describe ____________ 3 - Other. Describe ____________	37	64	_
d. Burning of solid waste at site: 00 - None 01 - Incineration 02 - Open burning of all or most combustibles 04 - Open burning on restricted basis. Describe ____________ 08 - Other. Describe ____________ 99 - Not applicable	38	65-66	_ _
e. Air pollution resulting from present operation: 0 - None noted, or not determined 1 - Potential. Describe ____________ 2 - Polluting emissions noted or reported. Describe ____________ 9 - Not applicable	39	67	_
f. Water pollution problem: 00 - None noted 01 - Surface irregular or otherwise conducive to allowing pools of water to collect. Describe ____________ 02 - Accumulations of water on disposal site. Was waste contacting this water? ____________ 04 - Adjacent to stream, lake, etc., and leeching into surface water appears likely. Indicate distance ____________ 08 - Leeching noted or reported. Describe ____________ 16 - High ground water level. Describe ____________ 32 - Other. Describe ____________ 99 - Not applicable	40	68-69	_ _
g. Water pollution resulting from present operation: 0 - None noted or not determined 1 - Potential. Describe ____________ 2 - Actual pollution noted or reported. Describe ____________ 9 - Not applicable	41	70	_

	Data No.	Column	Code
h. Salvaging at disposal site: 0 - No salvaging noted 1 - Salvaging not permitted 2 - Salvaging permitted 4 - Salvaging noted or reported. Describe ______ ______________________________ 9 - Not applicable	42	71	_
i. If residue results from operation of site, describe disposal: 1 - Sanitary landfill 2 - Dump 3 - Other. Describe ______________________ 9 - Not applicable	43	72	_
j. Other problems at disposal site: 00 - None noted 01 - Potential for insect and/or rodent breeding. Describe ______________________ 02 - Insect and/or rodent breeding noted or reported. Describe any control measures ___ ______________________________ 04 - Odor problem noted or reported. Describe any control measures ______________________ 08 - Disposal site unfenced. Is access by unauthorized persons a problem? ______________ 16 - Wind-blown paper. Describe ______________ ______________________________ 32 - Other. Describe ______________________ 99 - Not applicable	44	73-74	_ _
33. Distance from hospital to disposal site receiving most solid waste hauled from hospital (Code nearest mile. Indicate zeros if no waste is hauled away.) Distance to any other site ______________________	45	75-76	_ _
34. Card designator	46	80	4

Form HSW-5
8/68

Quantities Survey

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Description	Data No.	Column	Code
1. Name of hospital ______________________			
2. Hospital identification number	1	1-3	_ _ _
3. Survey date: Month	2	4-5	_ _
Day	3	6-7	_ _
Year	4	8-9	_ _
4. Day of Survey: 1 - Sunday 5 - Thursday 2 - Monday 6 - Friday 3 - Tuesday 7 - Saturday 4 - Wednesday	5	10	_
5. Length of time that waste was monitored, to nearest half hour	6	11-14	_ _ . _
6. Length of time necessary to monitor all waste collection within hospital, to nearest half hour. Specify hours ______________________	7	15-18	_ _ . _
7. Special conditions which might affect amount of solid waste generated per patient on survey day: 0 - None present 1 - Conditions with net effect tending to increase contribution per patient 2 - Conditions with net effect tending to decrease contribution per patient 3 - Conditions with unknown net effect on contribution per patient Specify conditions noted ______________________ ______________________	8	19	_

Section B. Survey Results - General	Data No.	Column	Code
8. Patient census for adult and pediatric cases (i.e.. all except newborn): Midnight Preceding Survey ________ Midnight Following Survey ________ Mean (Code This) ________	9	20-23	_ _ _ _
9. Newborn census: Midnight Preceding Survey ________ Midnight Following Survey ________ Mean (Code This) ________	10	24-26	_ _ _
10. Data for day of survey (midnight to midnight): a. No. of admissions ________ No. of births ________ Enter total in column at right ________	11	27-29	_ _ _
b. No. of discharges ________ No. of deaths ________ Enter total in column at right ________	12	30-32	_ _ _

	Data No.	Column	Code
11. Total amount of solid waste generated:			
a. Weight			
1. Weight measured: ___________			
2. Allowance for waste sent through grinders, if not measured directly ___________________			
Total ___________________	13	33-37	_ _ _ _ _
Enter total in column at right (full lb.)			
b. Volume			
1. Volume measured: ___________			
2. Allowance for waste sent through grinders, if not measured directly ___________________			
Total ___________________	14	38-41	_ _ _ _
Enter total in column at right (full cu. ft.)			
12. Contributions of solid waste per patient per day:			
a. Weight (nearest 0.1 lb./patient/day)	15	42-45	_ _ . _
b. Volume (nearest 0.1 cu.ft./patient/day)	16	46-49	_ _ . _
13. Contributions of solid waste per admission:			
a. Weight (nearest lb./admission)	17	50-52	_ _ _
b. Volume (nearest cu.ft./admission)	18	53-55	_ _ _
14. Density of solid waste (nearest 0.1 lb./cu.ft.):			
a. Average for all waste	19	56-58	_ . _
b. Average for combustible rubbish	20	59-61	_ . _
c. Average for non-combustible rubbish	21	62-65	_ _ . _
15. Maximum percent of solid waste weight collected in one hour:			
a. Total waste, except for waste diverted from grinders, incinerator residue, etc.	22	66-67	_ _
b. Combustible rubbish	23	68-69	_ _
(Enter nearest percent. Use zeros if not determined.)			
16. Time of maximum weight hour for total solid waste: 00 - Not determined 07 - 2-3 pm 01 - 8-9 am 08 - 3-4 02 - 9-10 09 - 4-5 03 - 10-11 10 - 5-6 04 - 11-noon 11 - 6-7 05 - noon-1 pm 12 - 7-8 06 - 1-2 13 - Other. Specify _______	24	70-71	_ _
Indicate time of maximum weight hour for combustible rubbish _______________			
17. If burnable material is incinerated on-site, indicate percent of incinerator capacity brought to unit in maximum hour (Enter nearest whole percent. Indicate zeros if not determined.)	25	72-74	_ _ _
Does indicated percent represent actual load on the incinerator? If not, explain ___________________ ___________________			
(Use data for major incinerator, as defined in item 6, form HSW-3.)			

	Data No.	Column	Code
18. Maximum percent of solid waste volume collected in one hour:			
a. Total waste, except for waste diverted from grinders, incinerator residue, etc. Specify hour ____________	26	75-76	__ __
b. Combustible rubbish. Specify hour ____________	27	77-78	__ __
(Enter nearest percent. Use zeros if not determined.)			
19. Card designator	28	80	5

Form HSW-6
8/68

Quantities Survey - Continuation 1

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification	Data No.	Column	Code
1. Name of hospital ____________________			
2. Hospital identification number	1	1-3	- - -
3. Survey Date: Month	2	4-5	- -
Day	3	6-7	- -
Year	4	8-9	- -

Section B. Survey Results - General (continued)	Data No.	Column	Code
4. No. of loads of solid wastes:			
a. By personnel assigned to waste collection	5	10-12	- - -
b. By other personnel. Describe ____________ ____________	6	13-14	- -
5. Average load:			
a. By weight (nearest lb.)	7	15-17	- - -
b. By volume (nearest cu. ft.) Enter zeros if not determined. Weight of average load for assigned personnel: ____________ lb.	8	18-19	- -
6. Maximum load:			
a. With regard to weight (nearest lb.)	9	20-22	- - -
b. With regard to volume (nearest cu. ft.) Enter zeros if not determined.	10	23-25	- - -

Section C. Survey Results - Solid Waste Disposal	Data No.	Column	Code
7. Enter, to the nearest percent, the portion of the total solid waste weight sent to each noted method. Indicate zeros for each method which is not available or for which waste was not measured. Waste classified in the waste inventory as disposed of by unknown or mixed methods should be allocated to the various methods, in proportion to the amounts of waste determined for each, as follows: 1. For mixtures, to the recorded components 2. For unknown, to all other components Do in sequence noted here, but only if disposal of at least 80% of waste weight is known.			
a. On-site methods:			
1. Incineration on-site	11	26-28	- - -
2. Grinding on-site	12	29-31	- - -
3. Mixed, other, and unknown -- on-site.	13	32-33	- -
Indicate breakdown ____________	14	34-36	- - -
b. Disposal after hauling away:			
1. Incineration	15	37-39	- - -
2. Sanitary landfill	16	40-42	- - -
3. Dumping	17	43-45	- - -
4. Hog feeding	18	46-48	- - -
5. Mixed, other, and unknown hauled away.	19	49-50	- -
Indicate breakdown ____________	20	51-53	- - -
c. Mixed on-site and hauled away	21	54-56	- - -
d. Other than preceding. Describe ____________ ____________	22	57-59	- - -
e. Unknown whether disposal is on-site, after hauling, etc.	23	60-62	- - -
8. Card designator	24	80	6

Form HSW-7
8/68

Quantities Survey - Continuation 2

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification	Data No.	Column	Code
1. Name of hospital ______________________			
2. Hospital identification number	1	1-3	_ _ _
3. Survey date: Month	2	4-5	_ _
Day	3	6-7	_ _
Year	4	8-9	_ _

Section B. Survey Results - Solid Waste Sources	Data No.	Column	Code
4. Enter, to nearest percent, the portion of the total weight of solid waste from each listed source. Indicate zeros for waste sources not present or not measured. Allocate wastes of unknown and mixed sources in the manner indicated for types of waste disposal on form HSW-6.			
1. Administrative and other offices	5	10-11	_ _
2. Central supply	6	12-13	_ _
3. Classrooms and other teaching facilities	7	14-15	_ _
4. Construction and/or demolition	8	16-17	_ _
5. Dietary facilities	9	18-19	_ _
6. Emergency	10	20-21	_ _
7. Extended care	11	22-23	_ _
8. Grounds	12	24-25	_ _
9. Hospitality shop	13	26-27	_ _
10. Housekeeping	14	28-29	_ _
11. Intensive care	15	30-31	_ _
12. Isolation	16	32-33	_ _
13. Laboratories	17	34-35	_ _
14. Laundry (including linen supply, sewing room, etc.)	18	36-37	_ _
15. Maintenance	19	38-39	_ _
16. Maternity	20	40-41	_ _
17. Morgue and/or autopsy facilities	21	42-43	_ _
18. Nursing stations, except as noted elsewhere	22	44-45	_ _
19. Outpatient department	23	46-47	_ _
20. Pediatric care	24	48-49	_ _
21. Pharmacy	25	50-51	_ _
22. Physical therapy	26	52-53	_ _
23. Psychiatric care	27	54-55	_ _
24. Public areas	28	56-57	_ _
25. Rehabilitation	29	58-59	_ _
26. Residences	30	60-61	_ _
27. Storerooms	31	62-63	_ _
28. Surgery	32	64-65	_ _
29. X-ray	33	66-67	_ _
30. Mixed	34	68-70	_ _ _
31. Other	35	71-72	_ _
32. Unknown	36	73-75	_ _ _
5. Card designator	37	80	7

Form HSW-8
8/68

Quantities Survey - Continuation 3

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification	Data No.	Column	Code
1. Name of hospital ______________________________			
2. Hospital identification number	1	1-3	_ _ _
3. Survey date: Month	2	4-5	_ _
Day	3	6-7	_ _
Year	4	8-9	_ _

Section B. Survey Results - Type of Solid Waste	Data No.	Column	Code
4. Enter, to nearest percent, the portion of the total weight for each listed type of waste. Indicate zeros for waste types not present or not measured. Allocate wastes of unknown and mixed types in the manner indicated for types of waste disposal on form HSW-6.			
1. Ashes	5	10-11	_ _
2. Biological material	6	12-13	_ _
3. Combustible rubbish	7	14-15	_ _
4. Construction and/or demolition waste	8	16-17	_ _
5. Garbage	9	18-19	_ _
6. Non-combustible rubbish	10	20-21	_ _
7. Radioactive wastes	11	22-23	_ _
8. Sweepings	12	24-25	_ _
9. Yard refuse	13	26-27	_ _
10. Mixed	14	28-30	_ _ _
11. Other	15	31-32	_ _
12. Unknown	16	33-35	_ _ _
5. Card designator	17	80	8

Form HSW-9
8/68

Personnel Study

Hospital Solid Waste Disposal in Community Facilities

Section A. Survey Identification	Data No.	Column	Code
1. Name of hospital ______________________			
2. Hospital identification number	1	1-3	_ _ _
3. Survey date: Month	2	4-5	_ _
Day	3	6-7	_ _
Year	4	8-9	_ _

Section B. Administration of Solid Waste Activity	Data No.	Column	Code
4. Indicate divisions of the hospital which are assigned solid wastes functions: 00 - No data 01 - Housekeeping 02 - Maintenance or engineering 04 - Food service 08 - Surgery 16 - Nursing, other than surgery. Describe involvement ______________________ 32 - Other. Specify ______________________	5	10-11	_ _
5. Indicate which division of the hospital has primary responsibility for the indicated solid waste activity or, if this is not defined, which is actually performing most of the activity: a. Collection or transfer of wastes within hospital: 0 - No data 1 - Housekeeping 2 - Maintenance 3 - Other. Specify ______________________	6	12	_
b. Disposal of solid wastes: 0 - No data 1 - Housekeeping 2 - Maintenance 3 - Other. Specify ______________________	7	13	_
6. Indicate to whom director of hospital division noted in 5a (i.e., waste collection) is responsible: 1 - Hospital director, administrator, asst. administrator, etc. 2 - Other. Specify ______________________	8	14	_

Section C. Personnel Data	Data No.	Column	Code
7. Give data for divisions of the hospital which are assigned solid waste functions: a. Housekeeping 1. Number of personnel with assignments including solid wastes activity (typical day)	9	15-17	_ _ _
2. Activities 00 - None 01 - Collection or transfer of wastes within hospital. Describe ______________________ 02 - Operation of incinerator. Describe ______________________ 04 - Maintenance. Describe ______________________ 08 - Other. Describe ______________________	10	18-19	_ _

	Data No.	Column	Code
3. Total number of housekeeping man-hours per day for solid waste	11	20-22	_ _ _
4. Average wage (nearest $0.10 per man-hour) for personnel considered in item 3. Indicate zeros if not applicable	12	23-25	_ . _
5. Job types of personnel involved ____________			
b. Maintenance and engineering			
1. Number of personnel with assignments including solid wastes activity (typical day)	13	26-27	_ _
2. Activities: 00 - None 01 - Collection or transfer of wastes within hospital. Describe ____________ 02 - Operation of incinerator. Describe ____ 04 - Maintenance. Describe ____________ 08 - Other. Describe ____________	14	28-29	_ _
3. Total number of maintenance or engineering man-hours per day for solid wastes	15	30-32	_ _ _
4. Average wage (nearest $0.10 per man-hour) for personnel considered in item 3. Indicate zeros if not applicable	16	33-35	_ . _
5. Job types of personnel involved ____________			
c. Food service			
1. Number of personnel with assignments including solid wastes activity, but excluding personnel who incidentally deposit food waste into grinders in the course of food preparation, dishwashing, etc. (typical day)	17	36-37	_ _
2. Activities: 00 - None 01 - Collection or transfer of wastes within hospital. Describe ____________ 02 - Operation of incinerator. Describe ____ 04 - Maintenance. Describe ____________ 08 - Other. Describe ____________	18	38-39	_ _
3. Total number of food service man-hours per day for solid wastes	19	40-42	_ _ _
4. Average wage (nearest $0.10 per man-hour) for personnel considered in item 3. Indicate zeros if not applicable	20	43-45	_ . _
5. Job types of personnel involved ____________			
d. Surgery			
1. Number of personnel with assignments including solid wastes activity (typical day)	21	46-47	_ _
2. Activities: 00 - None 01 - Collection or transfer of wastes within hospital. Describe ____________ 02 - Operation of incinerator. Describe ____ 04 - Maintenance. Describe ____________ 08 - Other. Describe ____________	22	48-49	_ _
3. Total number of surgery man-hours per day for solid waste	23	50-52	_ _ _
4. Average wage (nearest $0.10 per man-hour) for personnel considered in item 3. Indicate zeros if not applicable	24	53-55	_ . _
5. Job types of personnel involved ____________			
e. Other division of hospital. Specify ____________			
1. Number of personnel with assignments including solid wastes activity (typical day)	25	56-57	_ _

	Data No.	Column	Code
2. Activities: 00 - None 01 - Collection or transfer of waste within hospital. Describe ____ 02 - Operation of incinerator. Describe ____ 04 - Maintenance. Describe ____ 08 - Other. Describe ____	26	58-59	_ _
3. Total number of man-hours per day for solid waste. If several "Other" divisions of hospital are considered, indicate breakdown ____	27	60-62	_ _ _
4. Average wage (nearest $0.10 per man-hour) for personnel considered in item 3. Indicate zeros if not applicable. If several "Other" divisions of hospital are involved, indicate breakdown ____	28	63-65	_ . _
5. Job types of personnel involved ____			
8. Supervisory time devoted to solid wastes (hours per day):			
a. Housekeeping	29	66-67	_ _
b. Maintenance	30	68-69	_ _
c. Other. Specify ____	31	70-71	_ _
Indicate average wage per hour for each ____			
9. Total hospital personnel cost per ton of solid waste generated by hospital (nearest dollar)	32	72-73	_ _
10. Requirements for operational position with hospital division noted in 5a (i.e., waste collection):			
a. Education required: 0 - No education required 1 - No specific number of years completed, but must have certain knowledge. Describe ____ 2 - 1 to 6 years completed 3 - 7 to 9 years completed 4 - 10 to 11 years completed 5 - High school graduation 6 - Other. Specify ____ 9 - No policy	33	74	_
b. Experience required: 0 - No experience required 1 - No specific number of years, but must have certain knowledge or skills. Describe ____ 2 - More than 0 to 2 years 3 - More than 2 to 4 years 4 - More than 4 to 6 years 5 - More than 6 to 8 years 6 - More than 8 to 10 years 7 - More than 10 years 8 - Other. Specify ____ 9 - No policy	34	75	_
c. Other preferences and requirements ____			

Section D. Safety of Personnel	Data No.	Column	Code
11. Types of job-related injuries or infections among solid-wastes handling personnel: 00 - None noted 01 - Puncture from disposable needles. Describe ____ 02 - Injury from explosion. Describe ____ 04 - Cuts. Describe ____ 08 - Crushing or pinching. Describe ____ 16 - Infection. Describe ____ 32 - Other. Describe ____ Under "describe" indicate any available information on number of occurrences, causes, preventive action, etc.	35	76-77	_ _
12. Describe any protective clothing, etc., provided to solid waste personnel, other than incinerator operators ____			
13. Card designator	36	80	9